ARMY RESEARCH LABORATORY

Proceedings of the Symposium on Nuclear, Biological, and Chemical Contamination Survivability (NBCCS)

Developing Contamination-Survivable Defense Systems

Charles Braungart
BATTELLE

Louis S. D'Elicio
U.S. ARMY RESEARCH LABORATORY

ARL-CR-189 October 1994

prepared by

Battelle
2113 Emmorton Road, Suite 200
Edgewood, MD 21040

under contract

DLA900-86-C-2045

NOTICES

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1994	Final

4. TITLE AND SUBTITLE
Proceedings of the Symposium on Nuclear, Biological, and Chemical Contamination Survivability

5. FUNDING NUMBERS
C: DLA900-86-C-2045

6. AUTHOR(S)
Charles Braungart* and Louis S. D'Elicio

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: AMSRL-SL-CM
Aberdeen Proving Ground, MD 21010-5423

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: AMSRL-OP-AP-L
Aberdeen Proving Ground, MD 21005-5066

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ARL-CR-189

11. SUPPLEMENTARY NOTES
*Charles Braungart is employed by Battelle, 2113 Emmorton Park Road, Suite 200, Edgewood, MD 21040.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13 ABSTRACT *(Maximum 200 words)*

The 1994 Nuclear, Biological, and Chemical Contamination Survivability (NBCCS) Symposium was held on 15 June 1994 at the Edgewood Area Conference Center, Aberdeen Proving Ground, Maryland. Sponsored by the Chemical division of the American Defense Preparedness Association, it was cohosted by the U.S. Army Research Laboratory (ARL) and the U.S. Army Chemical and Biological Defense Command (CBDCOM).

The objective of the symposium was to provide a forum for the exchange of information on how to successfully execute an NBCCS program within the context of the item/system development and fielding program. Key to this exchange was the participation of both U.S. Government and industry members of the research, development, and acquisition community. Also key was the participation of the Joint Department of Defense (DOD) services. Selection of presentations was designed to help others avoid "reinventing the wheel" and to demonstrate that NBCCS can be achieved without "killing" a program.

The symposium demonstrated that significant progress has been made in the areas of design and testing for NBCCS of military systems. This process can be attributed to a strong government-industry team effort that must continue if this aspect of survivability is to be achieved on the battlefield.

14. SUBJECT TERMS
symposia, NBC contamination survivability, nuclear warfare, biological warfare, chemical warfare

15. NUMBER OF PAGES
185

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

INTENTIONALLY LEFT BLANK.

TABLE OF CONTENTS

INTENTIONALLY LEFT BLANK.

EXECUTIVE SUMMARY

The 1994 Nuclear, Biological, and Chemical Contamination Survivability (NBCCS) Symposium was held on 15 June 1994 at the Edgewood Area Conference Center, Aberdeen Proving Ground, Maryland. Sponsored by the Chemical Division of the American Defense Preparedness Association, it was co-hosted by the U.S. Army Research Laboratory (ARL) and the U.S. Army Chemical and Biological Defense Command (CBDCOM).

This symposium is the third in a continuing series. The first was held on 18-19 September 1991, and was hosted by the U.S. Army Chemical Research, Development and Engineering Center, Aberdeen Proving Ground, Maryland. The second was held on 3-4 December 1992, and was co-hosted by ARL and the U.S. Army Chemical and Biological Defense Agency (Provisional) (CBDA).

The objective of the symposium was to provide a forum for the exchange of information on how to successfully execute an NBC contamination survivability (NBCCS) program within the context of the item/system development and fielding program. Key to this exchange was the participation of both U.S. Government and industry members of the research, development, and acquisition community. Also key was the participation of the Joint Department of Defense (DoD) services. Selection of presentations was designed to help others avoid "reinventing the wheel" and to demonstrate that NBCCS can be achieved without "killing" a program.

A total of 16 presentations were given at this symposium. As compared with those at the 1992 event, these presentations differed in two ways. First, they involved the Joint DoD services, namely, the Army, Navy, and Air Force. Second, they included new topic areas, namely, modeling and simulation, and predictive methodologies applied to the selection of materials of construction. A total of 11 exhibits supplemented the information provided by the formal presentations. A list of exhibits is provided on page 203.

The symposium demonstrated that significant progress has been made in the areas of design and testing for NBCCS of military systems. This process can be attributed to a strong government-industry team effort that must continue if this aspect of survivability is to be achieved on the battlefield.

In publishing these proceedings, the hosting organizations seek to facilitate an effective and timely dissemination of technical information.

INTENTIONALLY LEFT BLANK.

WELCOME ADDRESS

Brigadier General George E. Friel, USA

Commander
U.S. Army Chemical and Biological Defense Command
Aberdeen Proving Ground, MD

Intentionally Left Blank

Today I want to join with Dr. John Lyons, of the U.S. Army Research Laboratory, and welcome you to the third NBC Contamination Survivability Symposium. I'd like to express my thanks and appreciation to the American Defense Preparedness Association for another exceptional job in the preparations for this forum. Much has happened over the past year in terms of actual technical progress in addressing NBC contamination survivability. This symposium will highlight and clarify current efforts. I also would note that this is a true Joint DoD effort. I am especially pleased to welcome the other services here and note that the Navy and Air Force will be presenting.

As both the Departments of the Army and Defense right-size and move toward a more mobile lethal force, it is imperative that defense systems are able to survive and sustain operations in a multi-threat battlefield environment. The chemical/biological threat remains substantial, and without our retaliatory capability, successful defensive measures to defense weapon systems become paramount. I believe the maturing of the U.S. Army Chemical and Biological Defense Command and the Survivability Analysis element in the U.S. Army Research Laboratory, and the teamwork that all of us in the survivability business are fostering, will definitely strengthen our ability to win on any future battleground.

Today we will update you on the NBCCS regulatory documents and provide you with highlights of survivability from some of your and our most important programs. Included are some of the ongoing modeling initiatives and a look at the future. These will help the developers in determining the design for survivability. We are here to discuss how we - the developers, the testers, the evaluators, the users - can ensure maximum readiness for our forces.

I ask all of you to aggressively participate in this forum and work together to create a strong NBC contamination survivability strategy for the future, which

should include innovative programs and procedures to address the survivability needs of our weapon systems.

Stop by the exhibits in our seminar area next door and view some of the latest information on NBC survivability.

Thank you again for your attendance and participation in this important symposium.

KEYNOTE ADDRESS

Dr. John W. Lyons

Director
U.S. Army Research Laboratory
Adelphi, MD

Intentionally Left Blank

General Friel. Distinguished ARL and CBDCOM engineers and scientists. Guests.

First, a brief thank-you to the folks from the Chemical-Biological Defense Command for co-hosting this meeting with the Survivability/Lethality Analysis Directorate of the Army Research Laboratory, and to the American Defense Preparedness Association for their help.

It is a pleasure to welcome all of you to our third symposium on the survivability of Army materiel to nuclear, chemical or biological environments. Most of you will remember that we held our first such meeting just after Desert Storm.

In fact, this issue of the survivability of Army equipment is a recent issue. Just ten years ago, all of our attention was focussed on protecting soldiers in these highly hazardous situations. The Army made them MOPP gear, we created water purification systems, we continued our work on the breathing apparatus soldiers wear when there is a risk of contaminated air. All of you here very likely had a hand in these advances.

Then it became apparent to decision-makers in the Army that there was more to the problem than had been considered. It became a first priority to ensure that the equipment soldiers use would not fail them in hazardous situations -- nuclear, chemical, biological.

NBC contamination survivability was initiated to examine the effects of potential agents and decontamination procedures on materiel, to look at the problem of decontaminability, and to ensure that the soldier can perform the required operational and maintenance tasks in the MOPP IV ensemble.

To assist the materiel developer, we have started to build a chemical defense materials data base. It contains the most available information on how the physical

properties of material are affected by the contamination and decontamination of materiel.

We hope that soon we will be able to construct a predictive model, complete with simulation, that will tell us exactly how certain contaminants will react with materials, give us a cost/benefit ratio during the system development process, and help soldiers survive with their equipment intact. This important job has just been made, if not easier -- then certainly more synergistic, by the collocation of ARL's Survivability/Lethality Directorate here in Edgewood, in close working proximity to the Chemical-Biological Defense Command.

We at ARL are also in a continuing process of bringing like missions together and one of the important ones is our Survivability/Lethality Analysis directorate. Soon, scientists from both the Woodbridge Research Facility in Virginia, which is closing in September under BRAC, and from what used to be the Harry Diamond Laboratories in Adelphi, will relocate here. For the first time, we will have what I call a critical mass to concentrate on these very important issues that bring you together today.

Let me tell you a little about the Army Research Laboratory's Survivability/Lethality Analysis Directorate (SLAD). ARL has nine other (and soon to be ten) technical directorates focussed on research and technology development, which is a primary business area for ARL. However, SLAD's mission is analysis and assessment of Army systems and materiel to ensure that it survives and prevails. Like the rest of ARL, SLAD's primary customer is the materiel development community. It is SLAD's role to be involved throughout the acquisition process to assist the materiel developer in building systems and equipment which have the required hardness characteristics, that can be decontaminated without damage, and that soldiers can use effectively in full chemical protective gear.

The capability to deploy highly lethal combat forces and sustainment assets rapidly from bases here and from forward locations abroad is fundamental to the success of our future military missions. As the Army's missions expand to include peacekeeping and humanitarian assistance, it appears ever more likely that we may face situations in hostile territory that could find an opponent using what we might consider "old" technology or technology specifically prohibited by international agreements -- and we need to be able to respond quickly and with confidence that our men and their equipment will survive.

Survivability may, at times, appear to take a back seat when a weapon system is conceived. But I am here today to say that we, collectively, must not let this happen.

I am encouraged and confident that significant progress has been and is being made in the implementation of NBC contamination survivability in various programs. The presentations that you are about to hear are not only oriented toward the incorporation of NBCCS characteristics into the end item configuration, but also toward initiatives under way in areas of material selection and modeling-simulation. They offer promise in predictive capabilities that will help us reduce expensive test scenarios.

I have several objectives for you. First, I want you to use this opportunity to communicate your technical accomplishments, problems, and the opportunities you see ahead. Second, I hope this symposium offers the forum by which to exchange the substantial knowledge base of the many organizations represented here today: government, industry, and academia. Finally, this symposium should enhance the cooperation and understanding among the various organizations here as, together, we pursue the most effective methods to ensure system survivability in a contaminated environment.

We must all keep in mind, as this symposium unfolds, that our ultimate customer is the soldier in the field, who is totally dependent on our capabilities to provide contamination-survivable equipment.

I'll be here most of the day and look forward to talking to as many of you as I can. Have a profitable symposium.

UPDATE ON NBCCS REGULATORY DOCUMENTS

Dr. William S. Magee

Advocate for NBC Survivability
Office of the Director for Chemical and Biological (CB)
Research, Development, and Acquisition
U.S. Army Chemical and Biological Defense Command
Aberdeen Proving Ground, MD

Intentionally Left Blank

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

UPDATE ON NBCCS REGULATORY DOCUMENTS

Dr. William S. Magee, Jr.
Office of the Director for Chemical
and Biological RDA

(410)671-3090
DSN 584-3090

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

UPDATE BRIEFING

- BACKGROUND
- STATUS
- CONCLUSION

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

BACKGROUND

NARROWING THE FIELD -

- CAMPAIGN
  - MISSION
    - ONE ON ONE
      - "SINGLE" HIT

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

BACKGROUND

DOCTRINAL NBC SURVIVABILITY	VS.	REGULATORY NBC CONTAMINATION SURVIVABILITY
☐ AVOIDANCE		☐ HARDNESS
☐ PROTECTION		☐ COMPATIBILITY
☐ DECONTAMINATION		☐ DECONTAMINABILITY

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

BACKGROUND

WAIVER OF REQUIREMENT vs. WAIVER OF CRITERIA/PROCEDURES

NDI IS AN ACQUISITION STRATEGY
NOT AN EXCUSE FROM REQUIREMENTS

NBCCS IS THE RESPONSIBILITY
OF THE MATERIEL DEVELOPER

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

BACKGROUND

INTENT

ACCEPTABLE MISSION

EFFECTIVENESS

(AME)

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

STATUS-GONE

DODI 4245.13 (15 JUN 87)	DESIGN/ACQUISITION OF NBC CONTAMINATION SURVIVABLE SYSTEMS
AFR 80-38 (29 SEP 89)	THE AF SYSTEMS SURVIVABILITY PROGRAM
SECNAVINST 3400.2 (4 MAY 88)	DESIGN/ACQUISITION OF NBCC SURVIVABLE SYSTEMS

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

STATUS-CURRENT

DODD	5000.1	DEFENSE ACQUISITION	23 FEB 91
DODI	5000.2	DEF ACQN MGT POLICIES & PROCEDURES	
DOD	5000.2M	DEF ACGN MGT DOCUMENTATION & REPORTS	
MEMO	(SECDEF)	SUBJ: WAIVER AUTHORITY	28 MAR 94
AR 70-1		ARMY ACQN POLICY	30 APR 93
AR 70-71		NBCCS OF ARMY MATERIEL	1 MAY 84
AR 15-41		NUC & CML SURV COMMITTEE	28 FEB 92
MEMO	(DCSOPS)	SUBJ: DA APPROVED CRITERIA	24 OCT 91
QSTAG 747		NBCD CONT SURV CRITERIA	14 AUG 91
TOPS 8-2-111/ 8-2-510		NBCCS SMALL/LARGE ITEMS	JUL 92

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

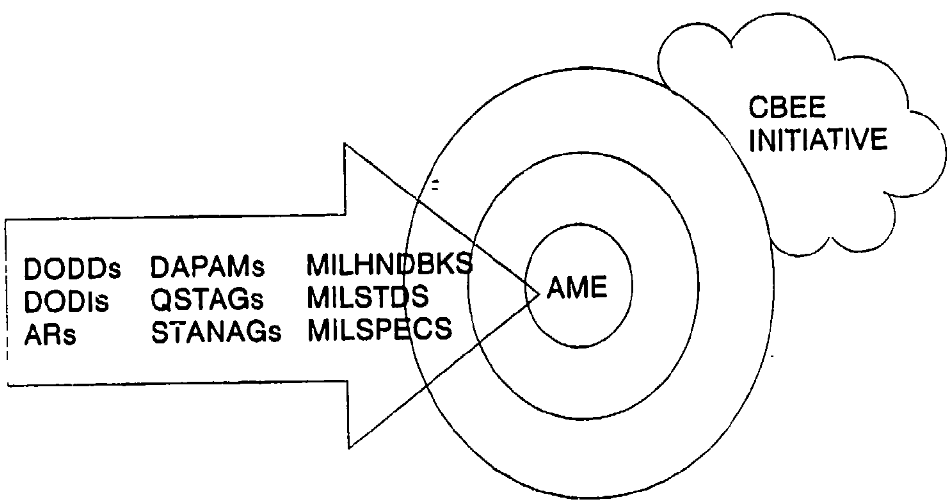
STATUS-COMING

(REV) DODD 5148.2	MISSION/FUNCTIONS OF ATSD(AE)
(REV) DODD 5160.5	RESPONSIBILITIES FOR RDA
AR 70-XX	SURV OF ARMY PERSONNEL/MATERIEL
DA PAM 70-XX	ARMY ACQN PROCEDURES
DA PAM 73-1 (REV)	TEST AND EVALUATION
AR 380-86 (REV)	CLASSIFICATION
STANAG	NBCCS

COMBINED BATTLEFIELD ENVIRONMENTAL EFFECTS (CBEE)

CBDCOM
US ARMY
CHEMICAL AND BIOLOGICAL
DEFENSE COMMAND

CONCLUSION-TAKING AME



Intentionally Left Blank

OVERVIEW OF MULTIPURPOSE INTEGRATED CHEMICAL AGENT ALARM (MICAD) PROGRAM

Mr. Frank Belcastro

MICAD Team Leader
U.S. Army Edgewood Research,
Development, and Engineering Center
Aberdeen Proving Ground, MD

Intentionally Left Blank

MULTI - PURPOSE INTEGRATED CHEMICAL AGENT ALARM

MICAD

BY:
FRANK J. BELCASTRO
CHEMICAL AND BIOLOGICAL DEFENSE COMMAND
(CBDCOM)

MICAD DESCRIPTION

- MICAD Is A Real Time NBC Warning And Reporting System
- Automatically Formats NBC Reports And Transmits Both Horizontally And Vertically On The Battlefield
- Provides Alarm To Individual Soldier
- Provides Inside/Outside Vehicle Sampling
- Provides RF Link For Remote Detection
- Employed In Area-Warning, Combat And Armored Vehicles, And Tactical Vans, And Shelters

Hardware Used

MICAD System Currently In 6.4 Development

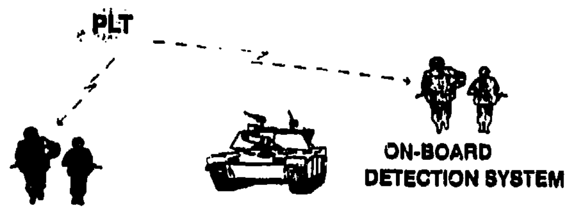
- **Display Control**
  - CPU W/Touch Panel Sceen
  - Interface Between Sub-systems And Communications Network
- **Sample Transfer System**
  - Provides Inside/Outside Air Sampling

Hardware Used

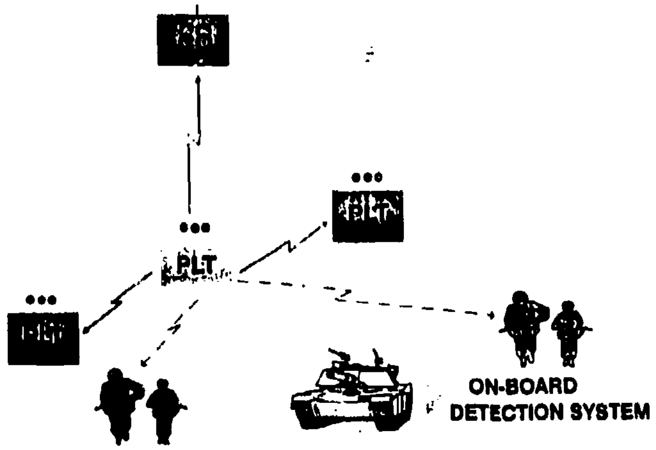
MICAD System Currently In 6.4 Development

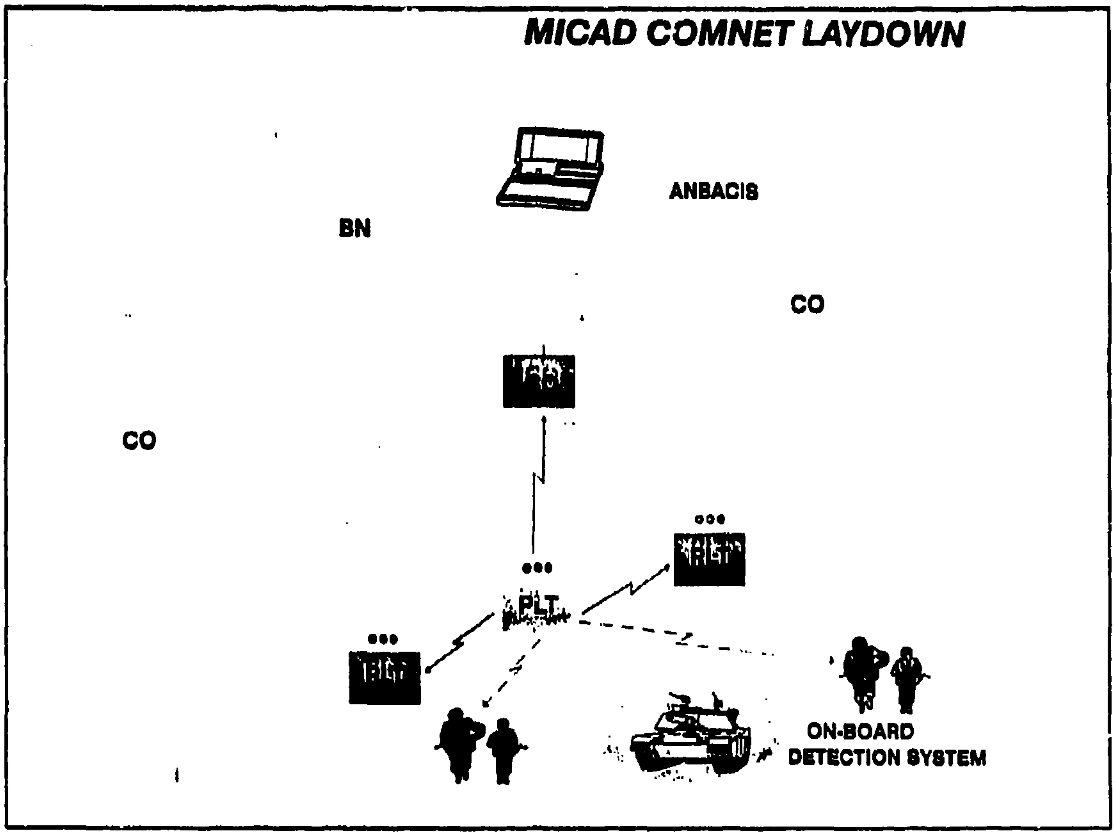
- **Telemetry Link**
  - Remote Detection Using RF
- **Alert Device**
  - Individual Warning
- **Interface Option Cables**
  - Contain Logic To Link Sub-system To Display Control

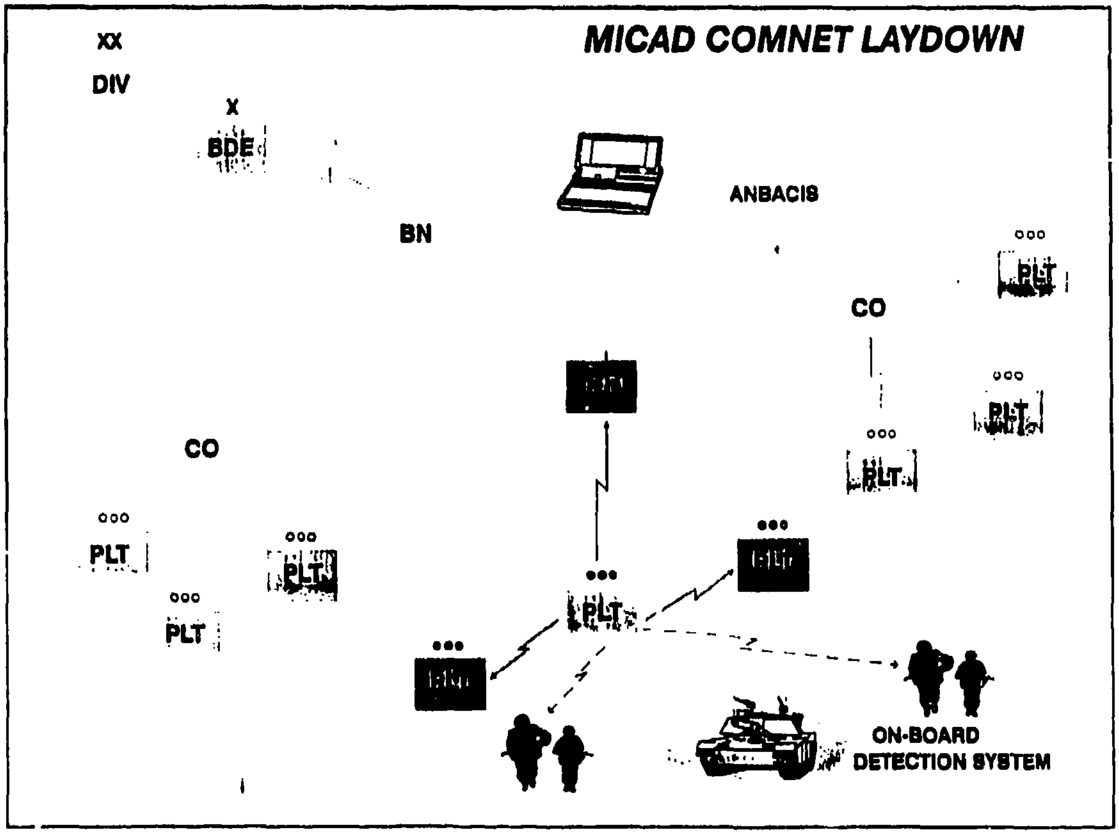
MICAD COMNET LAYDOWN



MICAD COMNET LAYDOWN




MICAD COMNET LAYDOWN
ANBACIS
BN
CO
CO
PLT
ON-BOARD
DETECTION SYSTEM


XX
DIV
X
BDE
MICAD COMNET LAYDOWN
ANBACIS
BN
PLT
CO
PLT
PLT
CO
PLT
PLT
PLT
PLT
ON-BOARD
DETECTION SYSTEM

Design Philosophy

- **True Concurrent Engineering**
- **Key Design Considerations**
  - Design To Unit Production Cost
  - Reliability
  - Maintainability
  - Producibility
  - Human Engineering
  - Value Engineering
  - Environmental Survivability
  - Electromagnetic Compatibility
  - NBC Survivability

Summary

- Aggresive NBC Survivability Program
- Data From Analysis And Test Has Been Fed Back Into The Design
- The Design To Include Materials Selection, Has Changed In order To Meet Or Exceed NBC Survivability Criteria

Intentionally Left Blank

MICAD NBCCS PROGRAM PLAN & TEST AND EVALUATION

Mr. Thomas M. McMahon

Head, Chemical Surety
Calspan Corporation
Buffalo, NY

Intentionally Left Blank

NBC Detection & Warning Now & 21st Century

The MICAD NBCCS Program at CALSPAN

BRUNSWICK DEFENSE CALSPAN LORAL Conic CSC FMC

MICAD NBCCS PLANNING, ANALYSIS, DESIGN AND TESTING PROGRAM

by

Thomas M. McMahon
and
Roland J. Pilie'

CALSPAN CORPORATION
Buffalo, New York

Presented at NBCCS Symposium at APG, 15 June 1994

LORAL Librascope

NBC Detection & Warning Now & 21st Century

The MICAD NBCCS Program at CALSPAN

BRUNSWICK DEFENSE CALSPAN LORAL Conic CSC FMC

ENGINEERING SUPPORT & TESTING

- BCCS Analysis and Design
  - CCS Preliminary Hardness Testing
  - CCS Material Decontaminability Testing
  - BCCS Functional Piece Part and Component Testing
- STS Design Enhancement
  - Improved Design STS Component and Bread Board Testing
    - LORAL–Team 6.4 STS Functional Testing

PRODUCTION PROVEOUT TESTING

- BCCS Testing of MICAD System Functional Components
- Functional Testing of Final Design STS Integrated Into MICAD System

LORAL Librascope

NBCCS Goals:

1. Achieve highest degree of NBCC survivability possible within mission performance design.
2. Achieve all NBCCS characteristics throughout design.

NBCCS Tradeoff Priorities:

- 1a. Hardness to Contaminants
- 1b. MOPP IV Compatibility
- 2. Hardness to Decontaminants
- 3. Decontaminability

The MICAD NBCCS Program
at
CALSPAN

MICAD NBCCS PROGRAM ACTIVITIES

- Engineering Support
  - Vulnerability Analysis
  - Materials Database Search/Selection
  - Hardware Design Enhancement
- Programmatic Support
  - Start of Work Meeting (SOWM)
  - System Requirements/Design Reviews (SRR, SDR)
  - Test Working Integration Group (TWIG)
  - Critical Design Review (CDR)
- Engineering Testing (ET)
  - CCS Materials Preliminary Hardness
  - CCS Materials Decontaminability
  - BCCS Piece Parts/Components
- Production Proveout Testing (PPT)
  - BCCS Components

OBJECTIVE OF THE VULNERABILITY ANALYSIS

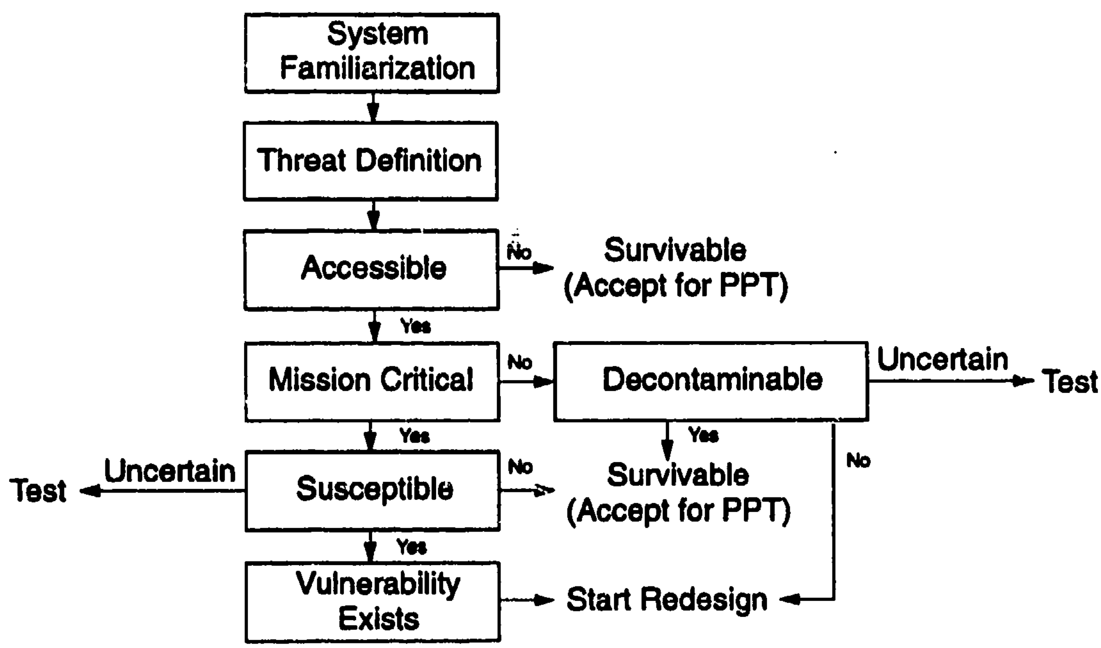
- To identify potentially vulnerable components of the MICAD systems as the design matures so that survivability specialists can work with design engineers to minimize BCCS problems

LORAL
Librascope

The MICAD NBCCS Program
at
CALSPAN

NBC Detection & Warning Now & 21st Century

SURVIVABILITY ANALYSIS APPROACH FOR MICAD



LORAL
Librascope

SUSCEPTIBILITY ANALYSIS APPROACH

- Decompose components to pieceparts; and pieceparts to materials
- Consult databases on materials/agents, decontaminant interactions, resulting property changes and decontaminability problems
- Examine influence of material property changes on ability of piecepart to function properly
  - Interact with designers to seek substitute for problem materials
  - Recommend materials and/or piecepart tests where data are inadequate
- Examine influence of degradation of piecepart function on the ability of each component to function properly
  - Interact with designers to correct problems that are uncovered
  - Recommend component tests where uncertainty exists
- Examine component configuration, assembly, bonding, and seal methods for potential hardness and/or decontaminability problems
  - Interact with designers to correct problems that are uncovered
  - Recommend component tests where uncertainty exists

LORAL Librascope

The MICAD NBCCS Program at CALSPAN

NBC Detection & Warning Now & 21st Century

Table 1B
SUMMARY OF BASELINE DATA ON ENCLOSURE MATERIALS

Name of Material	Data Reference	Data Summary	BBCS Recommendation
Ultem	CBIAC	Formulation number not specified. Samples not wetted by 10 to 15 µl drops of GD, HD or VX. No apparent effect after 3888 hours immersed in DS2 at 25°C.	
Ultem 2000 – No reinforcement	Calspan: Javelin Materials Decontaminability Tests	Hardness and Decontaminability demonstrated. (HD/DS2, VX/DS2, TGD/DS2)	
	Javelin System Tests	Crazing occurred at stress points with exposure to HD and DS2 and progressed with VX and TGT tests.	Do not use
Ultem 2300 -- 30% fiber glass (Original Housing Material)	Calspan: MICAD Prelim. Hardness Tests	No major hardness problems. Slight texture changes produced by HD, discoloration by DS2. Decontaminability data are not acquired in these tests.	Test for Decontaminability
Ecobond Adhesive	Calspan: MICAD Prelim. Hardness Tests	Tested butt–joint bonded Ultem. No hardness problems were observed.	Use
	Calspan: Mock Box Tests	Ecobond joints were hard to all agents and decontaminable.	

LORAL Librascope

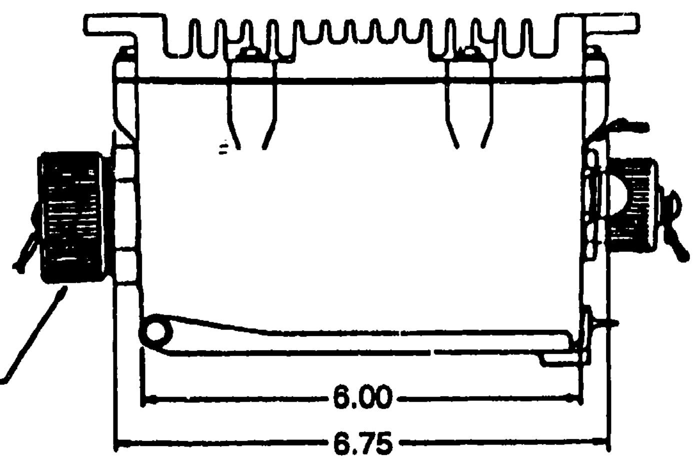
CRITICAL DESIGN REVIEW
UNIVERSAL INTERFACE UNIT (UIU)
KEY DESIGN ISSUES

- NBC SURVIVABILITY
- LOW COST
- RELIABILITY
- MAINTAINABILITY
- ENVIRONMENTAL SURVIVABILITY
  - THERMAL
  - SHOCK AND VIBRATION
- FLEXIBILITY
- ELECTROMAGNETIC COMPATIBILITY
- HUMAN ENGINEERING

LORAL Librascope

The MICAD NBCCS Program at CALSPAN

DISPLAY/CONTROL CONSOLE

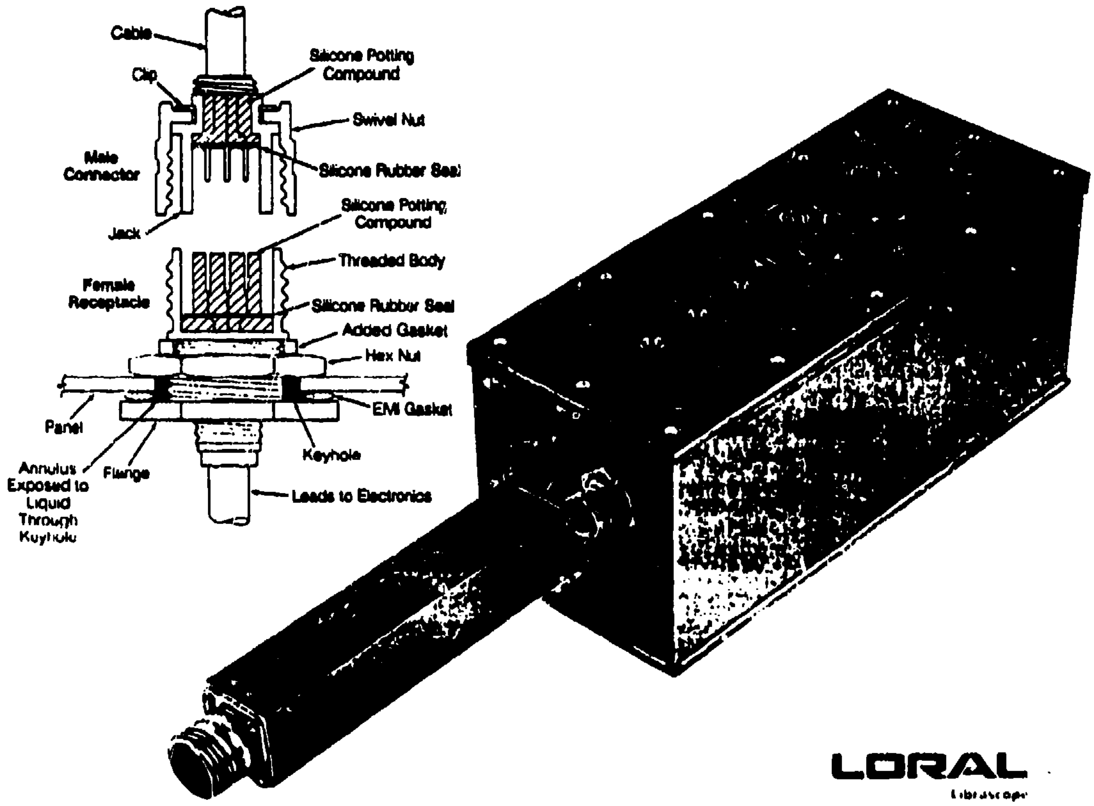


Battery Access Cover

LORAL Librascope

UNIVERSAL INTERFACE UNIT

LORAL
Librascope



Photograph of MICAD Mock Assembly Box # 1 with Insert Sketch of IA Connectors

The Test Sequence

1. Baseline Performance Test.
2. Contaminate with Biological Simulant.
3. Decontaminate with 2.5% Sodium Hypochlorite.
4. Performance Test.
5. Contaminate with HD, 10 g/m^2.
6. Decontaminate using Methods Prescribed by PM.
7. Contact Hazard Measurements.
8. Desorption (Offgassing) Measurements.
9. Contact Hazard Measurements.
10. Performance Test.
11. Repeat 5 through 10 with VX.
12. Repeat 5 through 10 with TGD.

Some simple electrical performance tests are run while the test articles are in the contaminated condition.

MICAD NBC Detection & Warning Now & 21st Century
The MICAD NBCCS Program at CALSPAN
BRUNSWICK DEFENSE CALSPAN LORAL Conic CSC FMC

Component Piece Part Test Articles

Part Name/Test Description	Part Number	Location	Functional Measurements
IA* Connectors, Female w/Male Caps J3,J4,J5	D38999/26WD35SN	Mock Box #1	Pin-to-Pin Insulation Resistance
IA Connectors, Male w/Female Caps, J3,J4,J5	D38999/26WD35PN	Mock Box #2	Pin-to-Pin Insulation Resistance
Power Connector #1	D38999/24WB5PN	Mock Box #1	Contact Resistance
Power Connector #2	D38999/24WB5PN	Mock Box #2	Contact Resistance
Power Connector #3	D38999/24WB5PN	Mock Box #3	Contact Resistance
LEDs, Style 1, #1,#2,#3	M19500/519-02	Mock Box #1	Luminosity
LEDs, Style 2, #1,#2,#3	M19500/519-02	Mock Box #2	Luminosity
Binding Posts #1, #2,#3	M55149/8-PB 08N	Mock Box #3	External-to-Ground Resistance External-to-Internal Resistance
In-Line Power Connector #1, Smooth Plastic	GC4816ANF15-35-15	Separate	Contact Resistance, Pin-to-Pin Insulation Resistance
In-Line Power Connector #2, Textured Plastic	GC4816ANF15-35-15	Separate	Contact Resistance,Pin-to-Pin Insulation Resistance
In-Line Power Connector #3, Steel	GC4816ANF15-35-15	Separate	Contact Resistance,Pin-to-Pin Insulation Resistance

LORAL Librascope

The MICAD NBCCS Program at CALSPAN

NBC Detection & Warning Now & 21st Century

Typical Contact Hazard Test Data

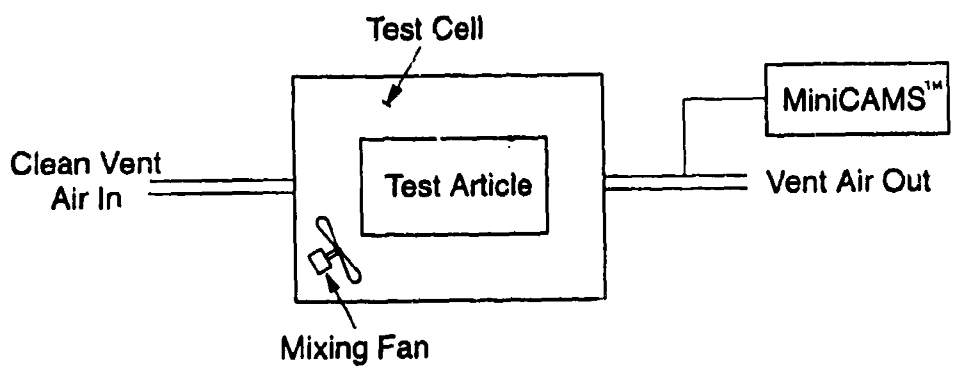
			CONTACT HAZARD TEST RESULTS - VX				
sample	article	condition	sample location	test#	uL	ng	ng/cm^2
VX-1	P.C.#1	post DS2	wrapped around harness on opposite side of in-line connector	G3T4	10	<0.25	≤10
VX-2	P.C.#1	post DS2	wrapped around harness just above in-line connector	G3T4	10	1.01	40.4
VX-3	P.C.#1	post DS2	wrapped around in-line connector	G3T4	10	0.81	32.4
VX-4	P.C.#2	post DS2	wrapped around harness on opposite side of in-line connector	G3T4	10	0.79	31.6
VX-5	P.C.#2	post DS2	wrapped around harness just above in-line connector	G3T4	10	2.75	110
VX-6	P.C #2	post DS2	wrapped around in-line connector	G3T4	10	7.55	302
VX-7	P.C.#1	post offgass	wrapped around harness on opposite side of in-line connector	G3T4	10	<0.25	< 10
VX-8	P.C.#1	post offgass	wrapped around harness just above in-line connector	G3T4	10	<0.25	< 10
VX-9	P.C.#1	post offgass	wrapped around in-line connector	G3T4	10	<0.25	<10
VX-10	P.C.#2	post offgass	wrapped around harness on opposite side of in-line connector	G3T4	10	<0.25	< 10
VX-11	P.C.#2	post offgass	wrapped around harness just above in-line connector	G3T4	10	<0.25	<10
VX-12	P.C.#2	post offgass	wrapped around in-line connector	G3T4	10	<0.25	<10
VX-13	P.C.#3	post DS2	wrapped around harness on opposite side of in-line connector	G3T6	10	<0.25	<10
VX-14	P.C.#3	post DS2	wrapped around harness just above in-line connector	G3T6	10	1.51	60.4
VX-15	P C.#3	post DS2	wrapped around in-line connector	G3T6	10	2.69	107.6
VX-16	M B #2	post DS2	sampler across LEDs #1 and #2	G3T6	10	0.32	12.8
VX-17	M.B.#2	post DS2	sampler wrapped around steel cap on in-line connector J3	G3T6	2.5	5.83	932.8
VX-18	M.B #2	post DS2	sampler wrapped around in-line connector J1	G3T6	10	0.70	28
VX-19	M.B.#2	post DS2	anodized aluminum in center of top surface of box	G3T6	5	8.77	701.6
VX-20	M.B #1	post DS2	sampler across LEDs #2 and #3	G3T7	10	<0.25	<10
VX-21	M.B.#1	post DS2	sampler wrapped around black cap on in-line connector J4	G3T7	10	9.52	380.8
VX-22	M B #1	post DS2	sampler wrapped around in-line connector J1	G3T7	10	10.75	430
VX-23	M B #1	post DS2	anodized aluminum of box top	G3T7	2	6.40	1280

LORAL Librascope

The MICAD NBCCS Program at CALSPAN

NBC Detection & Warning Now & 21st Century

THE DESORPTION RATE MEASUREMENT PROCEURE



$$\frac{dm}{dt} = V\frac{dc}{dt} = S(t) - L(t)$$

$$L(t) = C\,(R + K)$$

LORAL Librascope

The MICAD NBCCS Program at CALSPAN

MICAD — NBC Detection & Warning Now & 21st Century

BRUNSWICK DEFENSE · CALSPAN · LORAL Conic · CSC · FMC

Typical Desorption Rate Data

Test Item: Mock Box #2 Date: 3/9/94
Agent: VX

Elapsed Time [hours]	Mass Detected [ng]	Volume Sampled [L]	Ventilation Rate [L/min]	Desorption Rate [ug/min]	Cumulative Dose [ug]
0.09	146.26	1.85	90	4.23	21
0.59	182.76	1.19	120	14.39	453
1.09	38.84	0.32	120	16.87	959
1.59	[illegible].14	0.32	120	13.42	1362
2.09	25.81	0.32	120	10.93	1690
2.59	22.43	0.33	120	9.13	1963
3.09	19.91	0.32	120	8.00	2203
3.59	17.38	0.32	120	7.16	2418
4.09	16.05	0.32	120	6.42	2611
4.59	14.70	0.32	120	5.91	2788
5.09	13.59	0.32	120	5.43	2951
5.59	12.44	0.32	120	5.00	3101
6.09	11.66	0.32	120	4.63	3240
6.59	10.89	0.32	120	4.33	3370
7.09	10.07	0.32	120	4.03	3490
7.59	9.56	0.32	120	3.77	3604
8.09	9.02	0.32	120	3.57	3711
8.59	8.53	0.32	120	3.37	3812
9.09	8.18	0.32	120	3.21	3908
9.59	7.84	0.32	120	3.08	4000
10.09	7.34	0.32	120	2.92	4088
10.59	6.97	0.32	120	2.75	4170
11.09	6.65	0.32	120	2.62	4249
11.59	6.33	0.32	120	2.49	4324
12.09	5.97	0.32	120	2.36	4394

LORAL Librascope

The MICAD NBCCS Program at CALSPAN

MICAD — NBC Detection & Warning Now & 21st Century

BRUNSWICK DEFENSE · CALSPAN · LORAL Conic · CSC · FMC

SUMMARY OF OFFGASSING DATA FOR MOCK BOXES

$A_{min} = 0.013\ m^2$

Test Article Designation	Agent	Test Date	12 Hour Integrated Mass (mg)	Worst Case Exposure mg min/m^3	Pass/Fail Criteria mg min/m^3	Worst Case Corrected for Wind Fluctuations mg min/m^3
#1	HD	3/2/94	11.1	14.1	50	0.7
#2		3/2/94	9.5	12.2		0.6
#3		2/28/94	25.9	33.2		1.8
#1	VX	3/10/94	7.8	10.0	0.25	0.5
#2		3/9/94	4.4	8.6		0.28
#3		3/10/94	3.3	4.2		0.21
#1	GD	3/17/94	2.6	3.3	2.5	0.17
#2		3/16/94	0.6	0.7		0.04
#3		3/17/94	1.2	1.5		0.08

SUMMARY OF OFFGASSING DATA FOR IN LINE PIN CONNECTORS

$A_{min} = 7 \times 10^{-4}\ m^2$

Test Article Designation	Agent	Test Date	12 Hour Integrated Mass (mg)	Worst Case Exposure mg min/m^3	Pass/Fail Criteria mg min/m^3	Worst Case Corrected for Wind Fluctuations mg min/m^3
#1	HD	2/28/94	0.81	19.2	50	0.10
#2		3/1/94	1.54	36.6		0.18
#3		3/1/94	0.27	6.4		1.03
#1	VX	3/8/94	0.84	[illegible]	0.25	0.10
#2		3/8/94	0.72	[illegible]		0.09
#3		3/9/94	0.75	17.8		0.09
#1	GD	3/15/94	5.79	137.8	2.5	0.69
#2		3/15/94	0.55	13.2		0.07
#3		3/16/94	1.07	25.8		0.13

LORAL Librascope

FUNCTIONAL PERFORMANCE TEST RESULTS
Mock Box #2

	BIOLOGICAL			HD		VX			TGD	
	BASELINE TEST	POST DECON.	POST DECON.	DURING CONTAM	POST OFFGAS	DURING CONTAM	POST OFFGASS	POST OFFGAS	DURING CONTAM	POST OFFGAS
TEST#				G3T3		G3T6			G3T10	
DATE:	1/18/94	1/24/94	2/20/94	3/2/94	3/3/94	3/9/94	3/10/94	3/15/94	3/16/94	3/17/94
CELL#				3		2			3	

IA CONNECTOR PIN TO PIN INSULATION RESISTANCE TEST RESULTS
R (megohms)

J3 , PIN 1	>300k	7.0k	300k	>300k	>300k	>300k	172	17k	12k	8.8k
J3 , PIN 2	>300k	392	300k	>300k	>300k	>300k	182	27k	43k	19k
J3 , PIN 3	>300k	50k	300k	>300k	>300k	>300k	2.3k	33k	33k	25k
J4 , PIN 1	>300k	>300k	>300k	>300k	>300k	>300k	4.0k	150k	>300k	150k
J4 , PIN 2	>300k	>300k	>300k	>300k	>300k	>300k	3.0k	150k	>300k	300k
J4 , PIN 3	>300k	>300k	>300k	>300k	>300k	>300k	3.2k	300k	150k	300k
J5 , PIN 1	>300k	>300k	>300k	>300k	>300k	>300k	187	150k	>300k	100k
J5 , PIN 2	>300k	>300k	>300k	>300k	>300k	>300k	200	100k	>300k	12k
J5 , PIN 3	>300k	>300k	>300k	>300k	>300k	>300k	3.9k	150k	150k	150k
F S (volts)	300	300	300	300	300	300	300	300	300	300

LED LUMINOSITY TEST RESULTS
photometer output (Volts)

LED #1	0.95	0.92	0.85	functions	0.94	functions	0.91	0.91	functions	0.95
LED #2	1.85	1.83	1.57	functions	1.68	functions	1.69	1.69	functions	1.75
LED #3	1.66	1.59	1.44	functions	1.51	functions	1.48	1.48	functions	1.51

BCCS TEST RESULTS – HARDWARE

- BINDING POSTS
  - ALL BINDING POSTS PASSED ALL ELECTRICAL HARDNESS TESTS
  - THERE WAS NO EVIDENCE OF LEAKAGE AROUND BINDING POST MOUNTS
- LEDs
  - ALL LEDs PASSED ALL LUMINOSITY TESTS
  - SERIOUS CORROSION OCCURRED ON THE INTERIOR OF LED MOUNTS ON BOX #1. ISOLATED WATER MARKS AROUND CORRODED LEDs SUGGEST LEAKAGE THROUGH THE MOUNTS.
  - THERE WAS NO EVIDENCE OF CORROSION OR LEAKAGE THROUGH LED MOUNTS ON BOX #2.
- DISTORTION OF THE NI FILLED EPDM GASKET AND SERIOUS LEAKAGE INTO BOX #1

The MICAD NBCCS Program at CALSPAN

BCCS TEST RESULTS – HARDWARE

- IA CONNECTORS AND POWER CONNECTORS
  - ALL IA CONNECTORS AND POWER CONNECTORS PASSED ALL ELECTRICAL HARDNESS TESTS
  - THE BUTYL GASKETS SUCCESSFULLY ELIMINATED LEAKAGE THROUGH THE KEYHOLE IN RECEPTACLE MOUNTS
  - THE RECEPTACLES THAT WERE CAPPED WITH STAINLESS STEEL DUST COVERS REMAINED DRY THROUGH ALL TESTS
  - MOISTURE WAS OBSERVED INSIDE OF RECEPTACLES MATED TO CABLES AND TERMINATOR CAPS. INVESTIGATION STILL IN PROCESS

LORAL Librascope

(716) 631-6905

ARVIN
CALSPAN CORPORATION
ADVANCED TECHNOLOGY CENTER
P.O. Box 400, Buffalo, New York 14225

Thomas M. McMahon
Head, Chemical Surety Section
Physical Sciences Dept.

Intentionally Left Blank

OVERVIEW OF THE ARMORED GUN SYSTEM (AGS) PROGRAM

Mr. Albert P. Puzzuoli

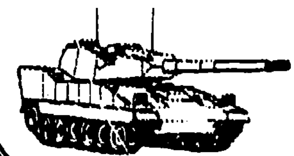
Deputy Project Manager
Office of the Project Manager
for the Armored Gun System
Warren, MI

Intentionally Left Blank

PEO ARMORED SYSTEMS MODERNIZATION

ARMORED GUN SYSTEM PROGRAM OVERVIEW

MR. ALBERT PUZZUOLI
DEPUTY PROJECT MANAGER
ARMORED GUN SYSTEM



15 JUNE 1994

AGS MISSION:

PROVIDE DIRECT FIRE SUPPORT FOR LIGHT FORCES WHERE TANKS ARE NOT AVAILABLE ...

- RAPID STRATEGIC DEPLOYABILITY
- CONTINGENCY FORCE AREAS OF OPERATION
- AIRBORNE; LIGHT INFANTRY; LIGHT ARMOR FORMATIONS
- REASONABLE SURVIVABILITY
- CONDUCT OFFENSIVE AS WELL AS DEFENSIVE OPERATIONS
- PROVIDE CAPABILITY TO DEFEAT TANKS IN CONJUNCTION WITH LONG RANGE ATGMs

AIR TRANSPORTABLE; READY TO FIGHT

WHAT AGS IS...

A LIGHT WEIGHT MOBILE GUN SYSTEM INTENDED TO REPLACE THE M551 SHERIDAN

- AIR DEPLOYABLE – AIRLAND & LOW VELOCITY AIR DROP
- MORE LETHAL, SURVIVABLE, DEPLOYABLE & SUPPORTABLE THAN M551

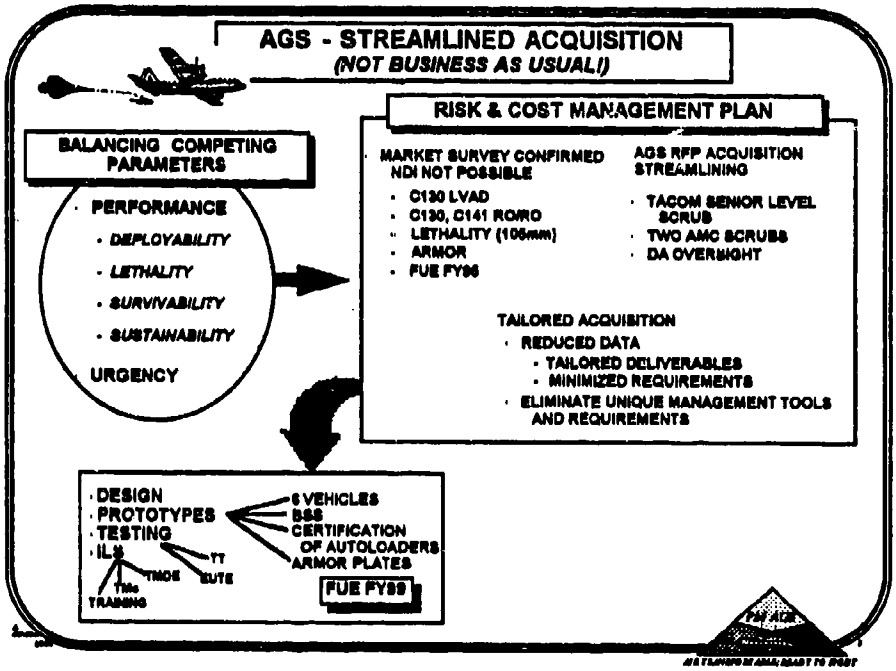
DESIGN BASED ON PROVEN NON-DEVELOPMENTAL (NDI) COMPONENTS & TECHNOLOGIES

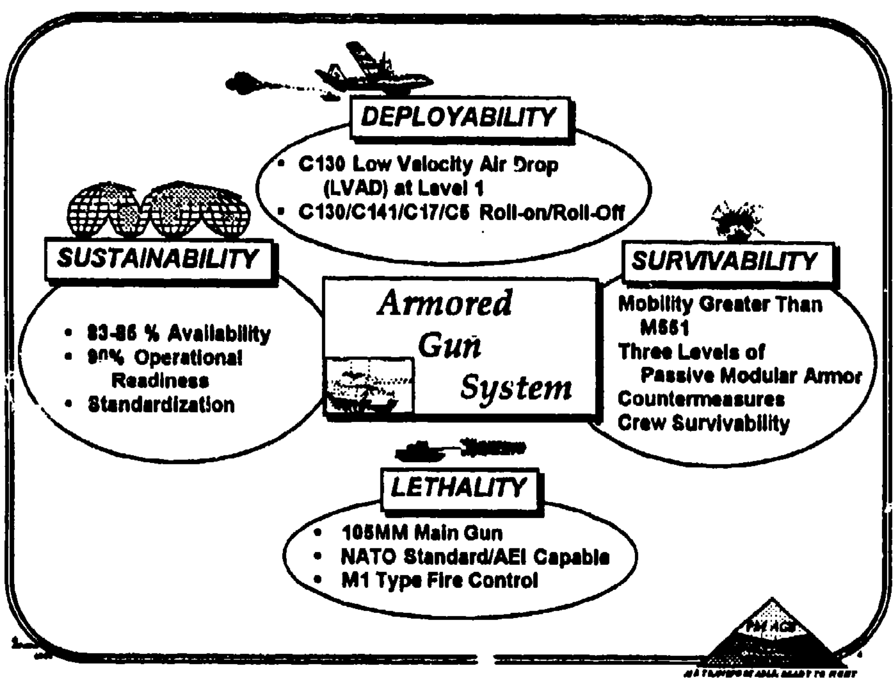
WHAT AGS IS NOT...

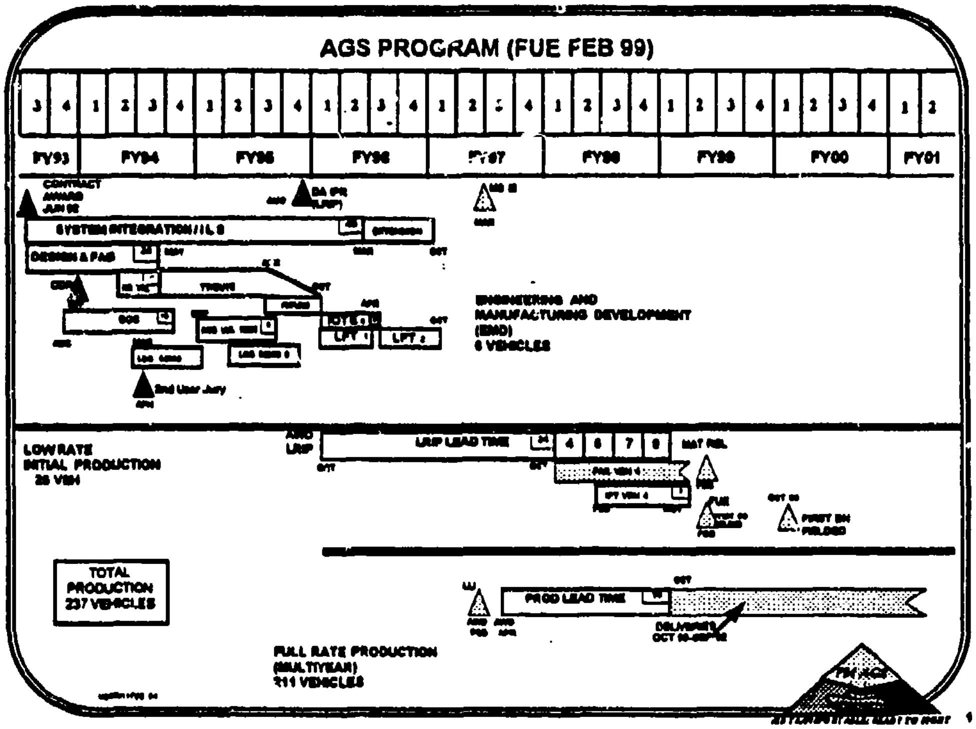
A MAIN BATTLE TANK

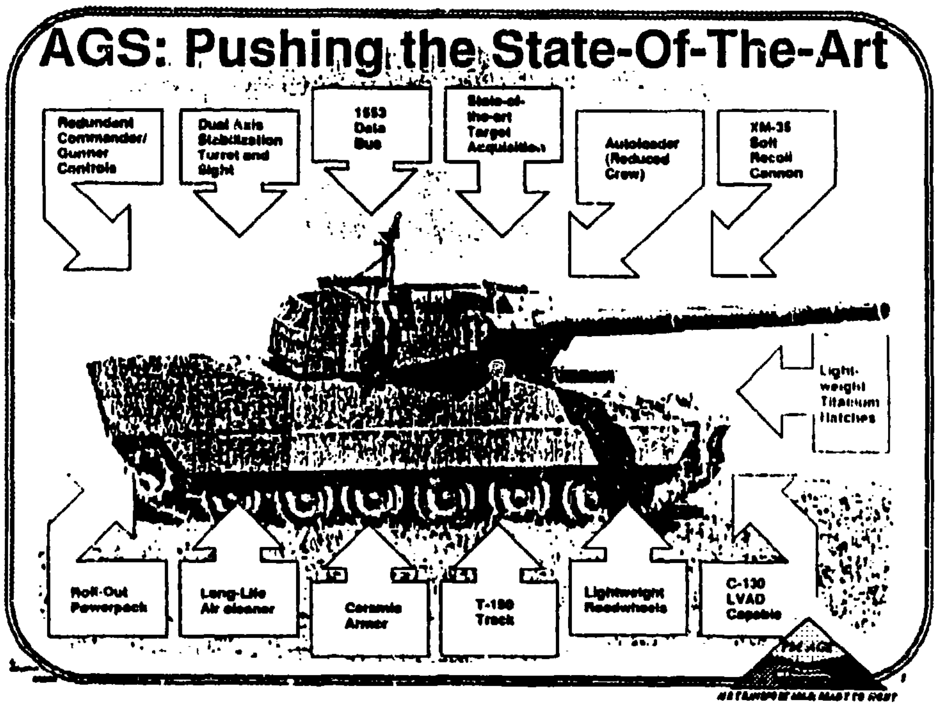
WHAT AGS CANNOT DO...

FIGHT TOE-TO-TOE WITH HEAVY TANKS ALONE!


AGS - STREAMLINED ACQUISITION
(NOT BUSINESS AS USUAL!)
BALANCING COMPETING PARAMETERS
PERFORMANCE
• DEPLOYABILITY
• LETHALITY
• SURVIVABILITY
• SUSTAINABILITY
URGENCY
RISK & COST MANAGEMENT PLAN
MARKET SURVEY CONFIRMED NDI NOT POSSIBLE
• C130 LVAD
• C130, C141 RO/RO
• LETHALITY (105mm)
• ARMOR
• FUE FY96
AGS RFP ACQUISITION STREAMLINING
• TACOM SENIOR LEVEL SCRUB
• TWO AMC SCRUBS
• DA OVERSIGHT
TAILORED ACQUISITION
• REDUCED DATA
• TAILORED DELIVERABLES
• MINIMIZED REQUIREMENTS
• ELIMINATE UNIQUE MANAGEMENT TOOLS AND REQUIREMENTS
• DESIGN
• PROTOTYPES
• TESTING
• ILS
6 VEHICLES
BSS
CERTIFICATION OF AUTOLOADERS
ARMOR PLATES
TT
TMDE
SUTE
TMs
TRAINING
FUE FY99
PM AGS


DEPLOYABILITY
• C130 Low Velocity Air Drop (LVAD) at Level 1
• C130/C141/C17/C5 Roll-on/Roll-Off
SUSTAINABILITY
• 83-85 % Availability
• 90% Operational Readiness
• Standardization
Armored Gun System
SURVIVABILITY
Mobility Greater Than M551
Three Levels of Passive Modular Armor
Countermeasures
Crew Survivability
LETHALITY
• 105MM Main Gun
• NATO Standard/AEI Capable
• M1 Type Fire Control
PM AGS


AGS PROGRAM (FUE FEB 99)
FY93
FY94
FY00
FY01
SYSTEM INTEGRATION/ILS
DESIGN & FAB
ENGINEERING AND
MANUFACTURING DEVELOPMENT
(EMD)
6 VEHICLES
LOW RATE
INITIAL PRODUCTION
26 VEH
LRIP LEAD TIME
TOTAL
PRODUCTION
237 VEHICLES
PROD LEAD TIME
FULL RATE PRODUCTION
(MULTIYEAR)
211 VEHICLES


AGS: Pushing the State-Of-The-Art
Redundant Commander/ Gunner Controls
Dual Axis Stabilization Turret and Sight
1553 Data Bus
State-of-the-art Target Acquisition
Autoloader (Reduced Crew)
XM-35 Soft Recoil Cannon
Light-weight Titanium Hatches
Roll-Out Powerpack
Long-Life Air cleaner
Ceramic Armor
T-150 Track
Lightweight Roadwheels
C-130 LVAD Capable

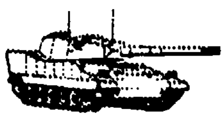
NBC APPROACH

(Not Business As Usual)

- **Streamlined Acquisition Strategy (To include NBCCS)**
- **Contractor Given Total System Responsibility**
- **Performance Specs vs. Mil Specs**
- **Contractor Provides Upfront Assessment Plan**
  - **Eliminates Most Contractor Reporting Requirements**
  - **Contractor Still Liable To Meet End Requirements**

RESULTS

- **No Developmental NBCCS Hardware**
  - **Standard Collective Protection Components**
  - **Standard Detection/Warning Devices**
  - **MOPP IV Protective Over Garments**
- **No Environmental Control Systems**
- **CARC Paint**
- **Maximum Use of NBC Compatible Materials**



AGS PROGRAM NBCCS RISK ASSESSMENT METHODOLOGY

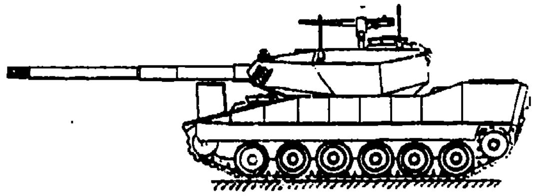
Mr. Francisco Magno

AGS NBCCS Project Engineer
United Defense L.P.
San Jose, CA

Intentionally Left Blank

Ground Systems Division
Santa Clara

Armored Gun System Vulnerability Analysis Methodology



15 June 1994

by
Francisco Magno
AGS NBCCS Project Engineer

Ground Systems Division
Santa Clara

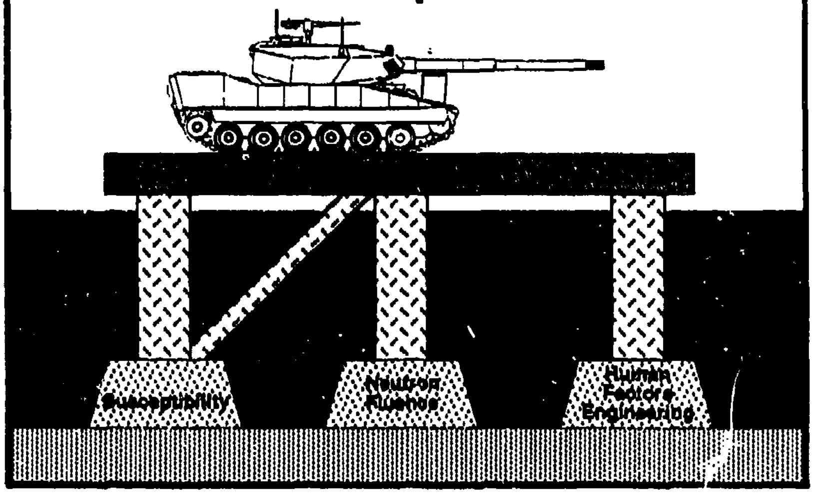
Presentation Focus

The presentation will focus on the susceptibility analysis portion of our NBCCS program. The goals of the presentation are:

- To show how the analysis works
- To show the benefits of our analysis
- To gain NBCCS community acceptance

Ground Systems Division
Santa Clara

Analyses Used to Support NBCCS Requirements



Ground Systems Division
Santa Clara

Susceptibility Analysis History

Developed under the United Defense ASM Subcontract

Presented by United Defense at the 2nd NBCCS Symposium in December 1992

Refined by United Defense in 1993 for the AGS to maximize the utility of the analysis and meet program objectives

Ground Systems Division
Santa Clara

Key Features of the AGS Method

AGS Refined

- Modeled after MIL-STD-1629a reliability analysis FMECA (Failure Modes Effect and Criticality Analysis).

AGS Refined

- Rank orders NBCCS risks by mission criticality and probability of damage occurring .

- Takes into account realistic threat levels.

Ground Systems Division
Santa Clara

Key Features of the AGS Method (continued)

AGS Refined

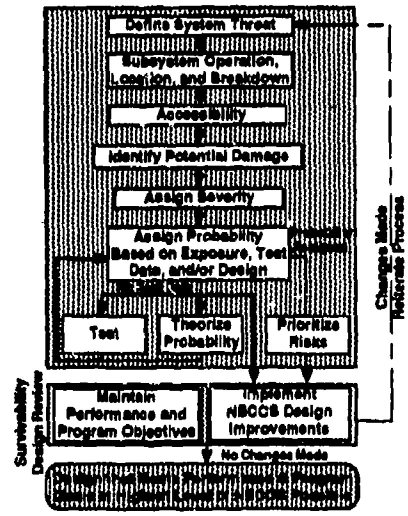
- Maximized utility
  - Analysis is cost effective. Analysis time is reduced by allowing engineers to predict damages at the highest level that is necessary to predict damages rather than starting tho analysis at the lowest piece-part level.

    AGS Refined
  - Method allows us to use information generated by reliability (functional block diagrams and predicted modes of failures).

    AGS Refined
  - Feedback is given at all stages of the design cycle, i.e. design guidance can be given by PDR, as the design matures the predicted damages are re-evaluated.
  - Concurrent engineering is embedded in the method.

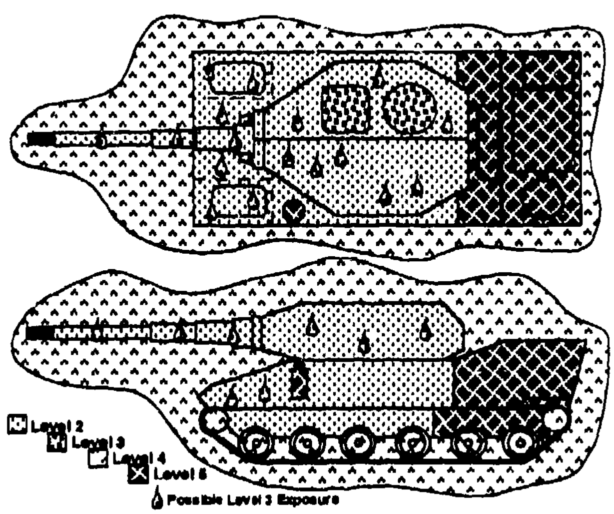
Ground Systems Division
Santa Clara

Process Flow Diagram



Ground Systems Division
Santa Clara

AGS Threat Levels



Ground Systems Division
Santa Clara

Prediction of Damages

How is the item being exposed? → What are the historical damages? → Does the damage cause a hazard or affect fit, form, or function? → List Predicted Damages

- **What is the level of agent exposure?**
- **Will it be in contact with decon and to what extent?**
  - FM 3-5 specifies a 90 minute deliberate decon time in which 10 minutes is dedicated to interior decontamination application.

Ground Systems Division
Santa Clara

Criticality Analysis

Damage Prediction → Effect on Item (Local Effect) → Effect on Mission (End Effect) → Assign Criticality Based on Ground Rules

- **Ground Rule Example**
  - Crew has ample time to don protective gear to continue mission in a contaminated environment, meaning that agent desorption affects availability and degrades follow-on mission.
- **Use FMECA data**
- **Categorize damages according to end effect:**

I - Catastrophic - causes death or weapon system loss
II - Critical - mission abort/loss
III - Marginal - delay/loss of availability or mission degradation
IV - Minor - results in unscheduled maintenance or repair

Ground Systems Division
Santa Clara

Assignment of Probability (Index) of Occurrence

Agent Exposure Level → Decon Exposure Based on Location & FM 3-5 → Test Data Interpretation → Assign Probability (Index)

Level A - Insured: 100%

Level B - Frequent: 70% ≤ Prob Occ < 100%

Level C - Reasonable: 40% ≤ Prob Occ < 70%

Level D - Occasional: 10% ≤ Prob Occ < 40%

Level E - Remote: 1% ≤ Prob Occ < 10%

Level F - Unlikely: Prob Occ < 1%

NOTE: use index to avoid the misleading definition of Probability

Ground Systems Division
Santa Clara

Susceptibility Table

Sub/Part Name	Material	Damage Mode	Cause	Local	End Effect	Sev	Prob of Occ	Mitigation Plan	Other
Power Dist Unit / Elect Harness	N/A	Elec -tricity not passed	matl degrad. or bad design	No Elect Power	Cannot Fire Weapn	II	D	Apply Raychem Heat Shrk for P3I	Vapor only. Decon exp low
Power Dist Unit / Elect Harness	Viton Sheath. Silicone Potting	Absorp	Agent	Off-gas	Crew Remain in MOPP	III	C	Same	Same
Power Dist Unit / Elect Harness	N/A	Trapping	Agent	Off-gas	Crew Remain in MOPP	III	F	Same	Same

- All columns not required for pre-assessment
- Sort by severity and probability of occurrence
- Add column to list system function by priority
  - Move, See, Shoot, Survive, Communicate, Tow

Ground Systems Division
Santa Clara

Impact of Susceptibility Analysis on AGS

Material

- Changed from silicon to EPDM for sealing applications on hatches and electronics **Exposure**
- Relocated turret exhaust fan to lower threat level in autoloader compartment **Test**
- Performed DS2 testing on armor tile adhesive because of its high priority **Design**
- Designed seat cushions to be easily removal **Educate**
- Elevated importance of scheduling NBCCS electrical design changes into pre-production improvement stages: protective heat shrinks, switch covers, EPDM seals, parylene coated panels, and NBCCS-tested switches.

Ground Systems Division
Santa Clara

Lessons Learned

- Presentation of analysis results should be scheduled to provide input before key design decisions are set.
- GFE and NDI may have an adverse effect on the system's NBCCS because it is difficult to incorporate changes to the design.
- A test program is imperative to positively identify and eliminate NBCCS risk areas because of the lack of usable test data.
- To prevent NBCCS from being a hidden requirement, NBCCS should be an integral part of concurrent engineering and design approval.

Summary of Analysis Key Points

- The method evolved from a need to cost-effectively identify NBCCS risk of complex system.
- The analysis methodology allows identification of risks at all stages of designs and enables us to provide feedback before key design decisions are set.
- Risks can be prioritize so that efforts can be aimed at the most critical areas impacting the system survivability.
- Acceptance of an analysis method is required to standardize NBCCS approaches.

NBCCS IN THE TACTICAL QUIET GENERATOR (TQG) PROGRAM

Ms. Kelly Alexander

Project Engineer
Office of the DoD Project Manager
for Mobile Electric Power
Springfield, VA

Intentionally Left Blank

Brief On 3-60kW

Tactical Quiet Generator Sets
NBC Contamination Survivability

to

American Defense Preparedness Association

15 June 1994

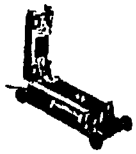
Kelly Alexander
Project Engineer, PM-MEP

Tactical Quiet Generators
Required Operational Capability (ROC)

- 3kW Through 200kW
- Multi-Fuel (JP-8, JP 4, JP-5, DF-1, DF-2, DF-A)
- Reduced Noise and IR Signature Levels
- More Reliable
- Less Weight
- HAEMP Protected
- Reduced Fuel Consumption
- Total Package Fielding (Logistically Supportable)
- Power Units/Power Plants
- Less Cost (Procurement, Support, Cost)
- Transportable (EAT, 5 & 10 kW, Air Drop etc.)

Increased War Fighting Capabilities for Commanders:
Combat Multiplier Offsetting/Battlefield Deficiencies

Total TQG Program

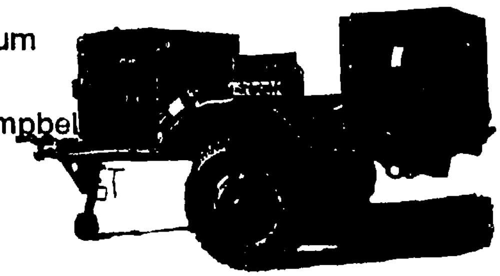


- Generators
  - 12 Models Replace 31
- Power Units/Power Plants
  - 19 Models Replace 54
- DISE
  - 5 Models
- Provides Electrical Power to Virtually all Army Systems
  - Weapon Systems
  - Communication Systems
  - Medical Systems
  - Combat Support Systems

13-MEP-001/94-3

5-60 kW TQG Current Status

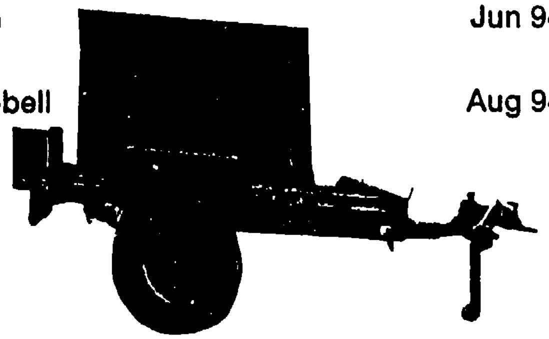
Material Release	Nov 93
First Unit Equipped - Fort Bragg	Dec 93
Fielding - Fort Drum	Jun 94
Fielding - Fort Campbell	Aug 94



13-MEP-001/94-4

5-60 kW TQG Current Status

Material Release	Nov 93
First Unit Equipped - Fort Bragg	Dec 93
Fielding - Fort Drum	Jun 94
Fielding - Fort Campbell	Aug 94



13-MEP-001/94-4

NBC Background

• TQG Waivers to AR 70-71	
- First Production	Approved Jun 92
- Rebuy	Approved Aug 93
• Dugway Paper Study	Complete
• Vulnerability Assessment	Complete Nov 93
• Chemical Contamination Survivability Test @ DPG	Oct 93-Jan 94
• Operational Effectiveness and Cost Trade-off Analysis (OECTA)	Jun 93 - Apr 94
• Brief NBCSC	Quarterly

13-MEP-001/94-5

NBCCS Waiver Background

- Approved 15 Jun 92; Rebuy Aug 93
- Waiver for Current Production of 17,000; Rebuy 17,000
- Required After Milestone III IPR
  - Vulnerability Assessment
  - Live Agent Test ASAP
  - Get Well Program
- Interim Solution
  - Manual Changes
- Coordinate with CRDEC, TECOM, Natick, and USANCA Regarding Design and Material Changes
- OECTA
- Brief NBCSC Quarterly

13-MEP-001/94-6

Vulnerability Assessment Findings

- Hardness to Decontaminants a Greater Problem than Contaminants
- Live Agent Testing Needed to Determine Hardness to Contaminants/ Decontaminants
- Protective Cover
  - Reduce Interior Levels of Contamination
  - Storage and Operation
- Air Filtration
- Alternate Methods of Decontamination
  - Decontaminants
  - Tailored Procedures
- Operational Considerations
  - Generator Set Disposal
  - Operation in MOPP

13-MEP-001/94-8

Chemical Contamination Survivability Test Plan

Phase I
Dynamic Liquid Simulant

- MES Applied to 5 kW and 60 kW TQGs @10 g/m2
- Internal and External Simulant Levels Measured with Swab Samples, Filter Paper, Printflex Cards and Minicam (After Application; Again After 8 Hours of Operation)
- Electrical Performance Test Conducted

13-MEP-001/94-9

Chemical Contamination Survivability Test Plan

Phase II
Static Decontamination

- One Cycle of Hot, Soapy Water or Steam Followed by Water Rinse
- One Cycle of DS2 Sprayed on TQG with M11 Apparatus
- Electrical Performance Test Conducted Between Cycles

13-MEP-001/94-10

Chemical Contamination Survivability Test Findings

After Phase I (Simulant Application)

- Both Sets Operating Within Specified Electrical Parameters
- Internal Contamination

After 8 Hours of Operation

- Both Sets Operating Within Specified Electrical Parameters
- Internal Contamination Measured by Minicam Reduced by a Factor of 10
- All Swab Samples Measured Zero Contamination

13-MEP-001/94-19

Chemical Contamination Survivability Test Findings

After Decontamination Cycles

- 5 kW Operable at 25, 50 and 75% Loads Only
- 60 kW Non-Mission Capable due to Failure of Voltage Regulator
- Both sets had Problems with CARC Peeling and Corroding
- Polyurethane Foam Coating Degraded, Peeling, Sagging
- Switch Box Inoperable
- Lettering on Fault Indicator Panel Erased
- Rubber Seals Around Doors Damaged

13-MEP-001/94-20

Operational Effectiveness and Cost Trade-off Analysis

Purpose

- Survey Commercial Market for Cost Effective Alternatives with Potential to Enhance Chemical Contamination Survivability of the TQG
- Provide Recommended Solutions to Deficiencies Resulting from Simulant Test at DPG

13-MEP-001/94-11

Comparison Techniques Used for Trade-off Analysis

- Operational Effectiveness (Weight, Performance, Size, Mobility, Power)
- Potential Survivability Enhancement
- Hard to Get ***Realistic*** Costs from Suppliers/ Manufacturers Without Requesting a Bid or Quote

13-MEP-001/94-12

Alternatives Considered

- Status Quo
- Contamination Avoidance
- Harden Vulnerable Areas of Generator Set

13-MEP-001/94-13

Recommendations to NBCSC

- Alternative II - Contamination Avoidance
  - Aerodynamic Filter
  - Cover Over Control Panel

  Issue as Field Installable Kit
- "Limited" Hardening
  - Near Term
    - -- Glass Dials/Gauges (All but two Currently use Glass)
    - -- Require Epoxy Sealant - No RTV Sealant
    - -- Lettering
  - Long Term
    - -- Replace Gaskets/Seals with Butyl Rubber (May Require Some Development)

13-MEP-001/94-17

Justification for Recommendations

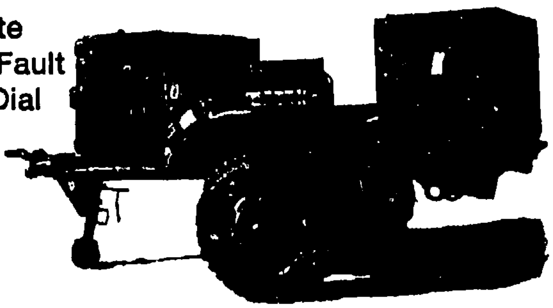
- Compatible with NDI Approach
- Cost Effective
- Operationally Effective
- Easily Implemented

13-MEP-001/94-18

Current Status

Implementation of Recommendations

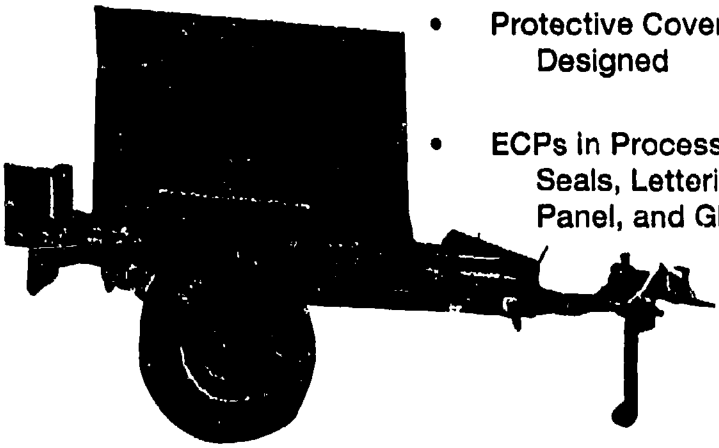
- Protective Cover and Air Filter Being Designed
- ECPs in Process to Substitute Sealant, Seals, Lettering on Fault Indicator Panel, and Glass Dial Covers



13-MEP-001/94-21

Current Status

Implementation of Recommendations



- Protective Cover and Air Filter Being Designed
- ECPs in Process to Substitute Sealant, Seals, Lettering on Fault Indicator Panel, and Glass Dial Covers

13-MEP-001/94-21

NBCCS IN THE 120 MM MORTAR PROGRAM

Mr. Edward Lewis

Project Engineer
Office of the Product Manager
for Mortar Systems
Picatinny Arsenal, NJ

Intentionally Left Blank

120MM BATTALION MORTAR SYSTEM

NUCLEAR, BIOLOGICAL AND CHEMICAL CONTAMINATION SURVIVABILITY SYMPOSIUM

MR. EDWARD LEWIS
PROJECT ENGINEER
PM MORTARS

PM MORTARS

PROGRAM HISTORY

- SYSTEM CONTRACT WITH MULTIPLE OPTIONS FOR RDTE AND PRODUCTION PERMITTING:
  - -- PURCHASE & TEST OF FOREIGN NDI WEAPONS & AMMO (FY88-90)
  - -- LIMITED OFF-SHORE PRODUCTION BUY TO FIELD THE 9TH INF DIV (FY 90)
  - -- ENHANCEMENT OF AMMO TO INCREASE PERFORMANCE (FY88-90)
  - -- CONUS PRODUCTION OF ENHANCED AMMUNITION (FY91)
- ALL SUBSEQUENT WEAPON PRODUCTION ON-SHORE BY WATERVLIET ARSENAL

PM MORTARS

NBC REQUIREMENT

ROC-MUST BE NUCLEAR AND NBC SURVIVABLE IAW AR 70-60. NBC CONTAMINATION SURVIVABILITY IS REQUIRED. THE SYSTEM IS MISSION ESSENTIAL.

PM MORTARS

NBC WAIVER

WAIVER OBTAINED APR 91 FROM NUCLEAR AND CHEMICAL SURVIVABILITY COMMITTEE WITH TWO STIPULATIONS:

- TEST THE BMS 120 AT DPG TO DETERMINE ACTUAL RESIDUAL HAZARD LEVELS USING STD FIELD DECON PROCEDURES AND PROVIDE RESULTS TO USER REPS AND COMBAT DEVELOPERS.
- ENSURE DOCTRINE AND UNIT STANDING OPERATIONAL PROCEDURES EMPHASIZE CONTAMINATION PREVENTION FOR THE BMS 120 WITH USE OF CHEMICAL PROTECTIVE COVERS.

PM MORTARS

120MM MORTAR
NBC EFFORTS

- ALTERNATE MATERIELS FOR WORST CASE MATERIELS
- DECONTAMINATION TEST ON BIPOD
- NBC COVER STUDY
- LOGISTICS CHANGES
- M67 SIGHT UNIT COATING

PM MORTARS

LESSONS LEARNED

- ADDRESS NBC REQUIREMENT AS EARLY AS POSSIBLE IN ACQUISITION CYCLE.
- UTILIZE EXPERTISE AND INFORMATION AVAILABLE FROM NBC COMMUNITY. DO NOT REINVENT THE WHEEL.
- VIEW NBC SURVIVABILITY COMMITTEE SECRETARIAT AS AN ALLY.

PM MORTARS

Intentionally Left Blank

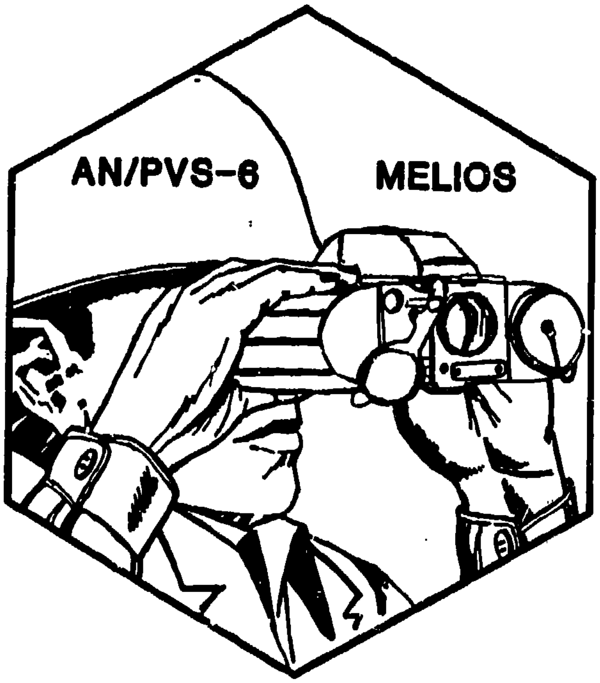
NBCCS IN THE MINI EYESAFE LASER INFRARED OBSERVATION SET (MELIOS) PROGRAM

Mr. Richard Renairi

Project Engineer
Office of the Project Manager
for Night Vision and Electro Optics
Fort Belvoir, VA

Intentionally Left Blank

MINI EYESAFE LASER INFRARED OBSERVATION SET



AN/PVS-6 MELIOS
SYSTEM DESCRIPTION

THE AN/PVS-6 MELIOS IS

A LIGHT WEIGHT, EYESAFE

LASER DISTANCE MEASURING SET

DESIGNED TO MEET THE NEEDS OF

INFANTRY AND OTHER SMALL UNIT LEADERS

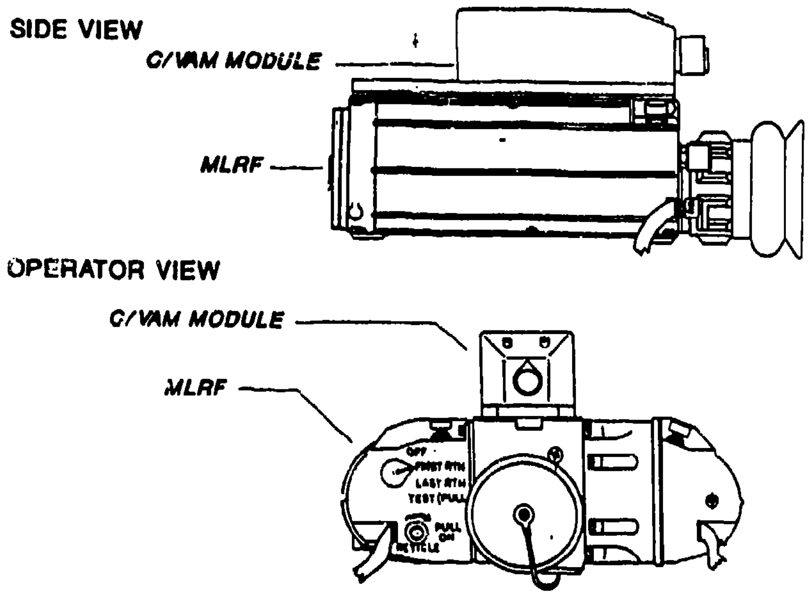
MELIOS PROGRAM HISTORY

- LOA APPROVED - - - - - - - - - - - JUN 81
- ADVANCED DEVELOPMENT - - - - - SEP 83 - SEP 88
  - 2 TECHNOLOGIES, BOTH SUCCESSFUL
- ROC APPROVED - - - - - - - - - - - DEC 87
- DPPO CONTRACT AWARDED - - - - -SEP 88
- DT/OT-II - - - - - - - - - - - - - - - - JAN - SEP 91
- C/VAM DEVELOPMENT - - - - - - - - APR 91 - OCT 93
- MILESTONE III REVIEW - - - - - - - - DEC 91
- PRODUCTION OPTION EXERCISED - -MAR 92
- C/VAM MILESTONE III REVIEW - - - -MAR 94
- C/VAM PRODUCTION OPTION EXERCISED - - APR 94
- FIRST UNIT EQUIPPED - - - - - - - - APR 94

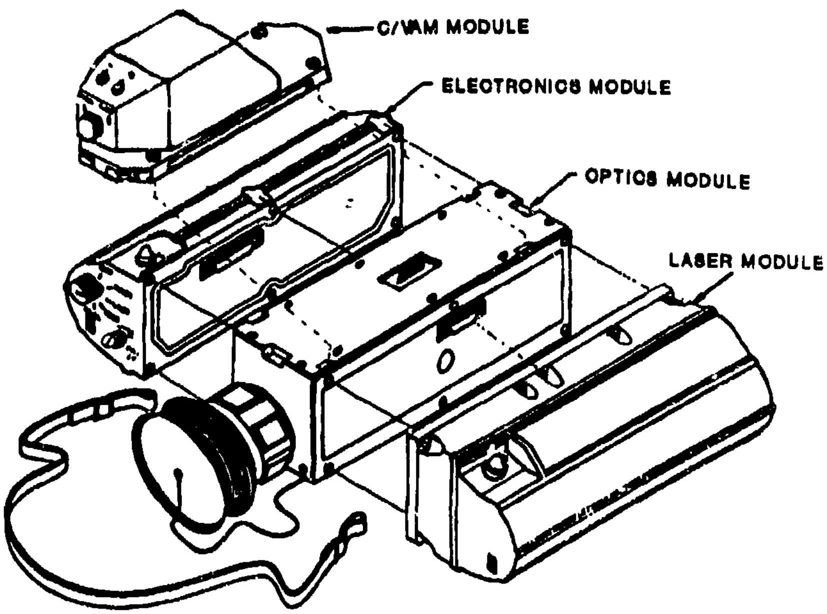
AN/PVS-6 MELIOS
MAJOR PLAYERS

ACQUISITION EXECUTIVE	PROGRAM EXECUTIVE OFFICER FOR INTELLIGENCE AND ELECTRONIC WARFARE
PROGRAM MANAGER	PROJECT MANAGER FOR NIGHT VISION AND ELECTRO-OPTICS
MATERIEL DEVELOPER	CECOM NIGHT VISION AND ELECTRONIC SENSORS DIRECTORATE
COMBAT DEVELOPER	US ARMY INFANTRY SCHOOL

AN/PVS-6 MELIOS
MLRF WITH C/VAM MODULE



AN/PVS-6 MELIOS
MLRF MODULARITY



MELIOS PERFORMANCE

PARAMETER	ROC REQUIREMENT	DEMONSTRATED
EYE SAFETY	EYESAFE AT APERTURE	EYESAFE AT APERTURE
OPTICAL HARDENING	HARDENED	HARDENED
MINIMUM RANGE	50 M RQD, 30 DESIRED	50 METERS
MAXIMUM RANGE	10,000 METERS	9995 METERS
RANGE ACCURACY	+/- 5 METERS	+/- 5 METERS
DISPLAY	IN EYEPIECE	IN EYEPIECE
COMPASS	+/- 10 MILS AZ & VAM	+/- 10 MILS AZ & VAM

MELIOS PERFORMANCE

PARAMETER	ROC REQUIREMENT	DEMONSTRATED
BATTERY	ONE STANDARD ARMY	BB-516 NICd
RANGINGS PER BATTERY	3,600 W/COMBAT BAT	500 WITH BB-516
LOW BATTERY INDICATOR	VISUAL IN EYEPIECE	VISUAL IN EYEPIECE
CARRYING CASE	REQUIRED	PROVIDED
SHIPPING/STORAGE CASE	REQUIRED	PROVIDED
OPTICAL CROSS SECTION	MINIMIZE	MINIMIZED

MELIOS PERFORMANCE

PARAMETER	ROC REQUIREMENT	DEMONSTRATED
RETICLE	VARIABLE ILLUM	VARIABLE ILLUM
DEPLOYMENT TIME		
- HAND HELD	20 SEC RQD, 10 DESR	17 SECONDS
- TRIPOD MOUNTED	70 SEC RQD, 60 DESR	41 SECONDS
COMPATIBILITY	WITH AN/UAS-11 WITH TWS	MET, ECP AT MICOM TEST SUMMER 94
CONOPS	(RANGINGS/MINUTE)	
- SUSTAINED RATE	6 RQD, 9 DESIRED	6 RANGINGS/MINUTE
- BURST RATE	9 RQD, 15 DESIRED	10 RANGINGS /MINUTE

MELIOS PERFORMANCE

PARAMETER	ROC REQUIREMENT	DEMONSTRATED
SECURITY	NO VISIBLE LIGHT INAUDIBLE AT 50 M	NO VISIBLE LIGHT INAUDIBLE AT 75 FT
RAM - MRBOMF - MEAN TTR (DS)	23,000 1.0 HOURS	34,990 0.2 HOURS
NUCLEAR SURVIVABILITY	HIGH ALTITUDE EMP	MET
ADVERSE WEATHER AND SMOKES/OBSCURANTS	WORK IN HOT, BASIC AND COLD CLIMATES; RANGE THRU SMOKES	CAN RANGE TO TARGETS VISIBLE IN EYEPIECE
TRANSPORTABILITY	AIR DROPPABLE CROSS COUNTRY	MET MET

AN/PVS-6 MELIOS
NBCCS REQUIREMENT

- MELIOS ROC REQUIREMENT
  - NBC CONTAMINATION SURVIVABILITY IS REQUIRED

- MELIOS PURCHASE DESCRIPTION
  - THE SHAPE OF THE MELIOS SHALL BE CONFIGURED IN A MANNER WHICH ALLOWS FOR USE WITH MOPP-IV PROTECTIVE CLOTHING AND/OR ARCTIC MITTENS.
  - COLOR AND FINISH. CHEMICAL AND BIOLOGICAL AGENT RESISTANT MATERIALS AND FINISHES PER MIL-C-46168 SHALL BE USED TO FACILITATE DECONTAMINATION AND USE OF THE MLRF IN A TOXIC ENVIRONMENT

AN/PVS-6 MELIOS
DESIGN CONSIDERATIONS

- HUMAN FACTORS
- MAINTAINABILITY
- HEMP SURVIVABILITY
- CHEMICAL SURVIVABILITY
- COST
- WEIGHT

AN/PVS-6 MELIOS

MATERIALS SELECTION CRITERIA

- CRDEC MANUAL CD-87033, NUCLEAR, BIOLOGICAL, AND CHEMICAL SURVIVABILITY METHODOLOGY, USED AS GUIDANCE FOR MATERIALS SELECTION
- MATERIALS USED MUST ALSO PROVIDE ENVIRONMENTAL SEALING OVER FULL TEMPERATURE RANGE, AND HEMP/EMI RESISTANCE
- NON-ESSENTIAL PARTS OF SYSTEM MAY BE THROW-AWAY

AN/PVS-6 MELIOS

MATERIALS USED

- OPTICS MODULE HOUSING - - - - A356.0-T6 ALUMINUM ALLOY
- OPTICS MODULE TOP COVER- - - A6061-T6 ALUMINUM ALLOY
- LASER MODULE BASEPLATE - - - - A7075-T6 ALUMINUM ALLOY
- LASER MODULE HOUSING - - - - - POLYPHENYLENE OXIDE RESIN COPPER-NICKEL PLATED FOR HEMP AND EMI RESISTANCE
- ELECTRONICS MODULE HOUSING - POLYPHENYLENE OXIDE RESIN COPPER-NICKEL PLATED FOR HEMP AND EMI RESISTANCE
- GASKETS - - - - - - - - - - - - - - CHLOROPRENE RUBBER
- ALL OUTSIDE SURFACES COATED WITH CARC

AN/PVS-6 MELIOS
DECONTAMINATION CONCEPT

- DECONTAMINATE MLRF WITH DS-2
- REPLACE THE FOLLOWING ITEMS AFTER OPERATION IN TOXIC ENVIRONMENT:
  - LENS COVER
  - EYESHIELD ASSEMBLY
  - EYESHIELD PLUG AND LANYARD
  - BATTERY CAP LANYARD
  - NECKSTRAP
  - CARRYING CASE

AN/PVS-6 MELIOS
TECOM NBCCS EVALUATION

- PAPER STUDY CONDUCTED BY DUGWAY PROVING GROUND JAN 90 TO DEC 91
  - TECOM PROJECT NO 8-EE-PVS-006-004
  - DOCUMENT NO DPG-LR-91-371
- REPORT CONCLUSIONS:
  - DS2 WILL DESTROY RUBBER EYECUP
  - STB WILL PIT ALUMINUM ALLOY A356
  - MODULAR DESIGN WILL TRAP AGENTS AND DECONTAMINANTS
  - RECOMMEND REDESIGN TO AVOID RECESSES
- DEVELOPER RESPONSE:
  - REPLACE EYECUP RATHER THAN DECONTAMINATE
  - ALUMINUM HOUSING IS COATED WITH CARC
  - PAINT FASTENERS WITH CARC AFTER ASSEMBLY

AN/PVS-6 MELIOS
USANCA RECOMMENDATIONS

- USE M-295 KIT FOR DECONTAMINATION INSTEAD OF DS-2
- CARC OVER FASTENERS ACCEPTABLE
- TEST OPTICS FOR HARDNESS AND DECONTAMINABILITY
- LIMITED WAIVER TO FIELD GRANTED PENDING TEST RESULTS

AN/PVS-6 MELIOS
HOW CAN WE IMPROVE THE PROCESS?

- BRING CHEMICAL EXPERTS ON PROGRAM NO LATER THAN START OF DPPO
- DEFINE HARDNESS REQUIREMENT AND DECONTAMINATION PHILOSOPHY IN OPERATIONAL REQUIREMENTS DOCUMENT
- ESTABLISH DECONTAMINATION CRITERIA AT BEGINNING OF DPPO
- MAKE CHEMICAL HARDNESS AND DECONTAMINABILITY A PART OF PURCHASE DESCRIPTION AND STATEMENT OF WORK
- IDENTIFY DECONTAMINATION PROBLEMS (RECESSED SCREWS, MATERIALS, ETC) BY CRITICAL DESIGN REVIEW AND CORRECT WHILE DESIGN IS STILL IN PAPER
- TEST TO DETERMINE THE LEAST DESTRUCTIVE WAY TO DECONTAMINATE

Intentionally Left Blank

VAPOR AND LIQUID TRANSPORT AND DIFFUSION MODELING (VLSTRACK)

Mr. Timothy J. Bauer

Chemical Engineer
Chemical and Biological Systems Analysis Branch
Naval Surface Warfare Center
Dahlgren, VA

Intentionally Left Blank

UNCLASSIFIED

CHEM-BIO SYSTEMS ANALYSIS BRANCH

INTRODUCTION

VLSTRACK

THE U.S. NAVY'S CHEMICAL/BIOLOGICAL AGENT VAPOR, LIQUID, AND SOLID TRACKING COMPUTER MODEL

by Timothy J. Bauer

Naval Surface Warfare Center
Dahlgren Division, Code B51
17320 Dahlgren Road
Dahlgren, VA 22448-5100
(703) 663-8621 DSN 249-8621
FAX (703) 663-4253

VLSTRACK is a user-friendly computer model which provides approximate chemical and biological warfare hazard predictions for a wide range of chemical and biological agents and munitions of military interest.

UNCLASSIFIED

1

UNCLASSIFIED

CHEM-BIO SYSTEMS ANALYSIS BRANCH

MODEL FEATURES

Current Versions
VLSTRACK 1.5.1
VLSTRACK 2.0

Computer System
UNIX Workstation
DOS-PC
Macintosh II
VAX/VMS
Other (FORTRAN compiler)

Screen Display
X-Window Input/Output
NDP Grex Input/Output
Tektronix Graphics Output
ASCII Character Input/Output

Parameter Input
Mouse/Keyboard- Windows
Keyboard- Numbered Menu

Agent Type
Persistent Chemical
Thickened Chemical
Dense-Vapor Forming
Dusty
Biological Organism or Toxin

Munition Type
Small Projectile
Bomb
Bulk-Filled Missile
Missile Containing Submunitions
Sprayer
User-Defined

Output Type
Deposition in mg/m2
Dosage in LCtx, ECtx, mg-min/m3
Concentration in particles/m3
Hazard at Detector Arrays

UNCLASSIFIED

2

UNCLASSIFIED

CHEM-BIO SYSTEMS ANALYSIS BRANCH

MODEL FEATURES (continued)

Dispersion Coordinates
Single Munition at Origin
Gaussian Random
Uniform Rectangular Random
Uniform Elliptical Random
(X,Y,T) Read From File
(Q, X, Y, Z, T) Puff Property Read

Meteorology Input
Constant (Screen or File)
Time Variable (Screen or File)
Vertical Profile+Time Variable (File)
Geographic Location+Time Variable (Files)
Full Space+Time Variable (Files)

Geographic Coordinates
Degrees
DDDMM.M
UTM Coordinates

Output Generation
Cumulative From Attack Time
Periodic For Each Time Period
Grid Sized to Contain Hazard
Fixed Geographic Region

Hazard Representation
Four Scaled, Rotated Color Contours Plus Uncertainty Brackets
Four Shaded Character Graphics Contours
Hazard Values Written to Output File

Detector Simulation
Passive
Active With Attack Information Known
Active With No Other Information

UNCLASSIFIED

3

UNCLASSIFIED

CHEM-BIO SYSTEMS ANALYSIS BRANCH

COMPUTATIONAL LIMITS

- 2500 Munitions or Bomblets
- 30 Detectors
- 201 by 201 Output Grid Points
- 72 Hours Total Hazard Prediction Time
- 24 Meteorology Forecast Time Periods
- 1 Minute to 24 Hours Time Period Duration
- 1500 Geographic Meteorology Locations
- 25 Vertical Meteorology Levels
- 25,000 Meters Height of Release
- 10,000 Total Vapor, Droplet, and Particle Clouds

UNCLASSIFIED

4

UNCLASSIFIED

NSWC Naval Surface Warfare Center DAHLGREN DIVISION

CHEM-BIO SYSTEMS ANALYSIS BRANCH

CURRENT STATUS

2167A Documentation
Operational Concept Document (OCD)
Software Requirements Specification (SRS)
Software User's Manual (SUM)
Software Design Document (SDD)
Software Test Description (STD)
Software Test Report (STR)- to be Written

Independent Verification and Validation (IV&V)
Verification Against a Matrix of 221Runs
Verification Report- to be Written
Validation Against 106 Field Trial Data Sets
Validation Report
Validation Against Complex Flow Field Trial Data- to be Done
Final Validation- to be Done

UNCLASSIFIED

5

UNCLASSIFIED

NSWC Naval Surface Warfare Center DAHLGREN DIVISION

CHEM-BIO SYSTEMS ANALYSIS BRANCH

CURRENT STATUS (continued)

NEW PC Version Released
VLSTRACK 1.5 and 1.5.1 Distributed to Replace VLSTRACK 1.2
VLSTRACK 1.0 (Nov 1990) and BIOTRACK (Feb 1991) Original Versions

VLSTRACK Integration Efforts
Naval Oceanographic Office (NAVOO):
Tactical Environmental Support System (TESS (3B))- v2.0
Mobile Oceanographic Support System (MOSS)- v1.2
Ballistic Missile Defense Office (BMDO):
Janus Wargame- v2.0.1
U.S. Army Nuclear and Chemical Agency (USANCA)-
CBD-Impact Regional Model- v2.0
Army Chemical School
Maneuver Control System (MCS)- v2.0

UNCLASSIFIED

6

```
VLSTRACK 1.5.1  6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100

enter input file name (return=VLSTRACK.DAT)
(end with .AMB for AMBACIS NBC-2/NBC-3 messages)
VLSEXAMP.DAT_

CURSER MOVEMENT AND PARAMETER SELECTION:

LEFT MOUSE: select parameter by clicking on region
RIGHT MOUSE: help on parameter region
RIGHT MOUSE BUTTON=RETURN in alphanumeric entries
KEYBOARD:  ENTER=choose region or selection
TAB=next column            SHIFT-TAB=previous column
PG-DN=next row             PG-UP=previous row
DN-ARROW=next selection    UP-ARROW=previous sel.
F1=help on selected item
<.>=directory on *.*       <.EXT>=directory on *.EXT
```

```
VLSTRACK 1.5.1  6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100
F1=help on item              MAIN ATTACK WINDOW           ?=keyboard commands

Munition                     Output Mode                  RUN PROGRAM
~100kg Bomb                  Cumulative

Chem/Bio Agent               Output File Prefix           Attack/Met. Opt Window
                             VLSEXAMP                      Options Selected

Date                         Map Scale                    Output/Comp Opt Window
August    2                  Fill Screen                   Options Selected

Local Attack Time                  Range                  Munition Prop. Window
1900        Dusk             Low:                              Defined
                             High:

Geographic Location               Selections               Meteorology Window
Deg Lat/Long                 VX                               Not Defined
39.0000N   78.0000W          GA (Tabun)
                             GB (Sarin)
True Trajectory Angle        GD (Soman)                     Detector Window
 45.0 deg                    GF                               None Defined
                             HD (Mustard)
Ground Surface Type          BIS (sim.)                    RECORD INPUT FILE
Grass                        TCP (sim.)
                             MS (sim.)
Output Type                  TEP (sim.)                     EXIT PROGRAM
Deposition                   Water (sim.)
                             Thickened VX
                                  More
                         UNCLASSIFIED
```

VLSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100

These are the chemical and biological agents contained in the chemical/biological agent parameter file VLSAGN.PAR. Other agents or variations can be added by editing the VLSAGN.PAR file.

Press any key to continue

UNCLASSIFIED

VLSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100

F1=help on item | METEOROLOGY WINDOW | ?=keyboard commands

Meteorology Input File
VLSEXAMP.MET

CONTINUE

Starting Forecast Time
1000

Next Time Period

Time Period
2 out of 3

Previous Time Period

True Wind Bearing
_

Range
Low: 0
High: 359

Wind Speed
10 km/hr

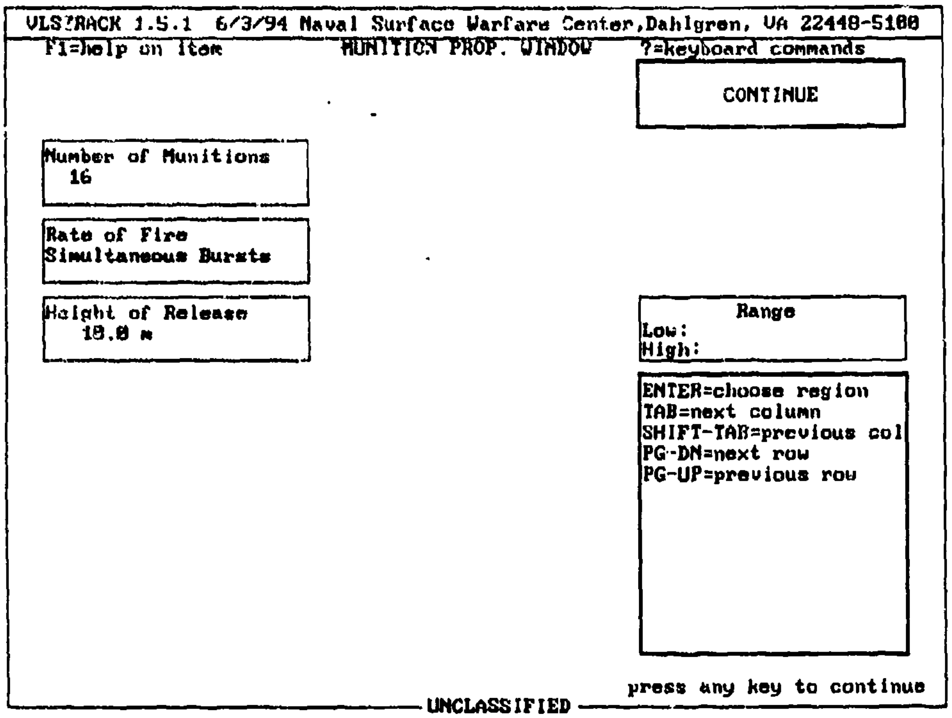
Selections

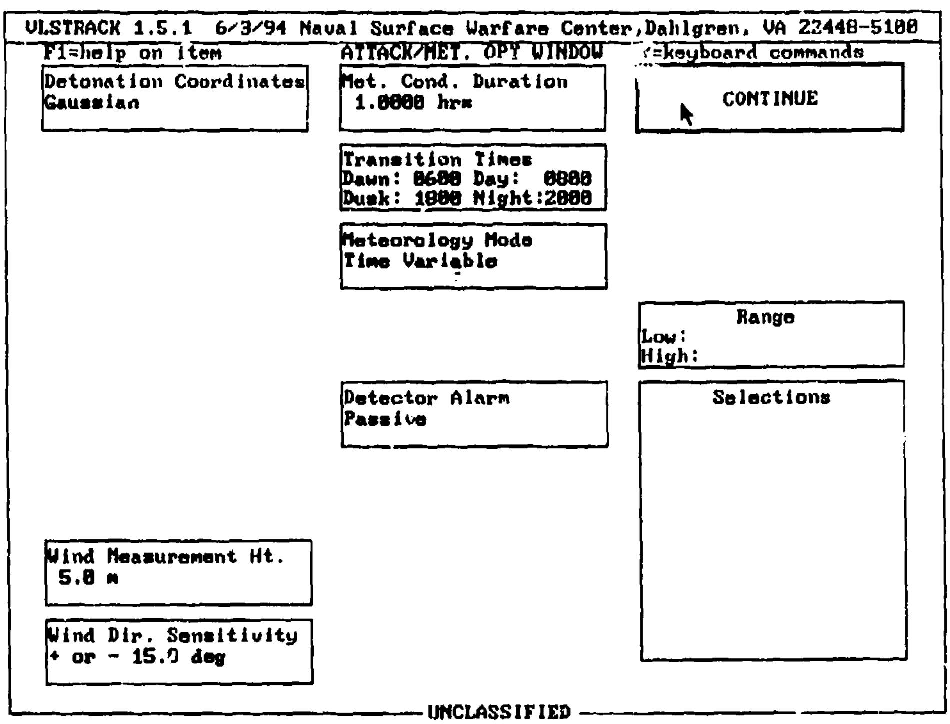
Pasquill Stab. Cat.
Determined by Program

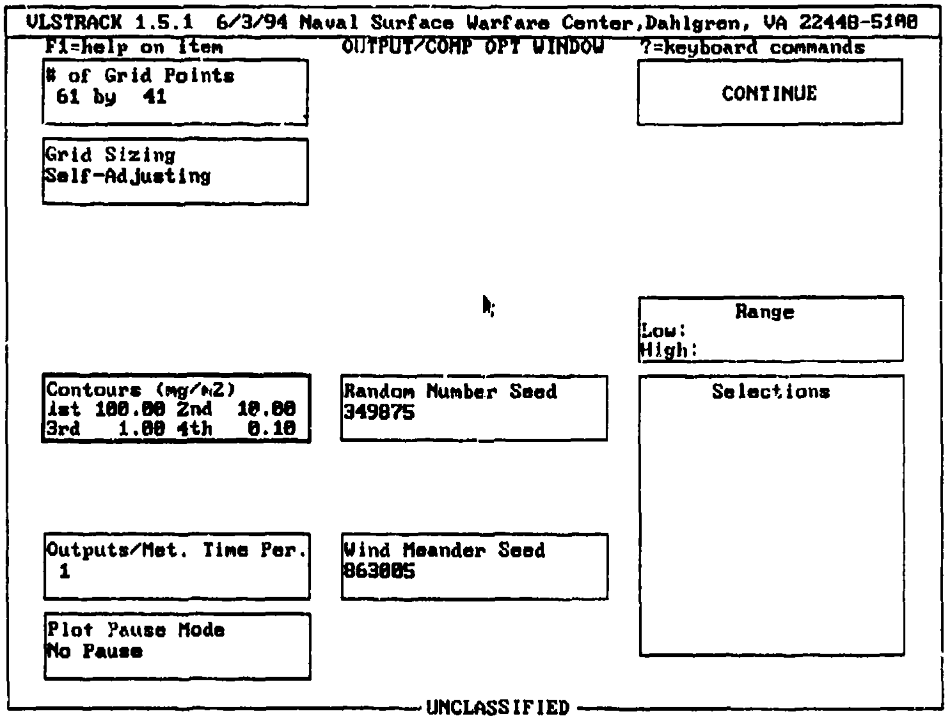
Air Temperature
25 C

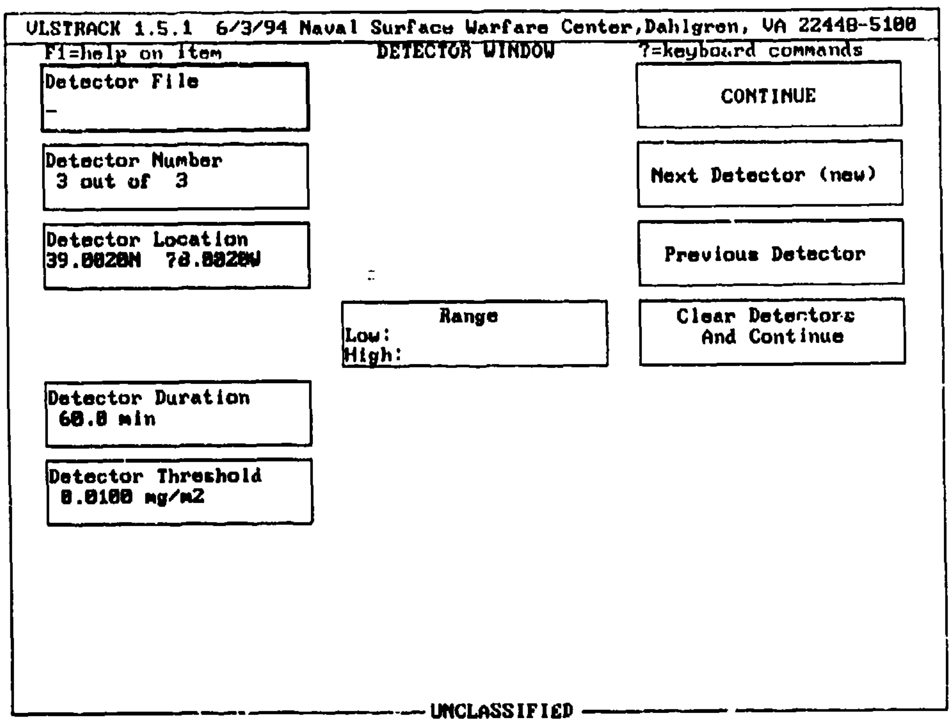
Cloud Cover
Partly Cloudy

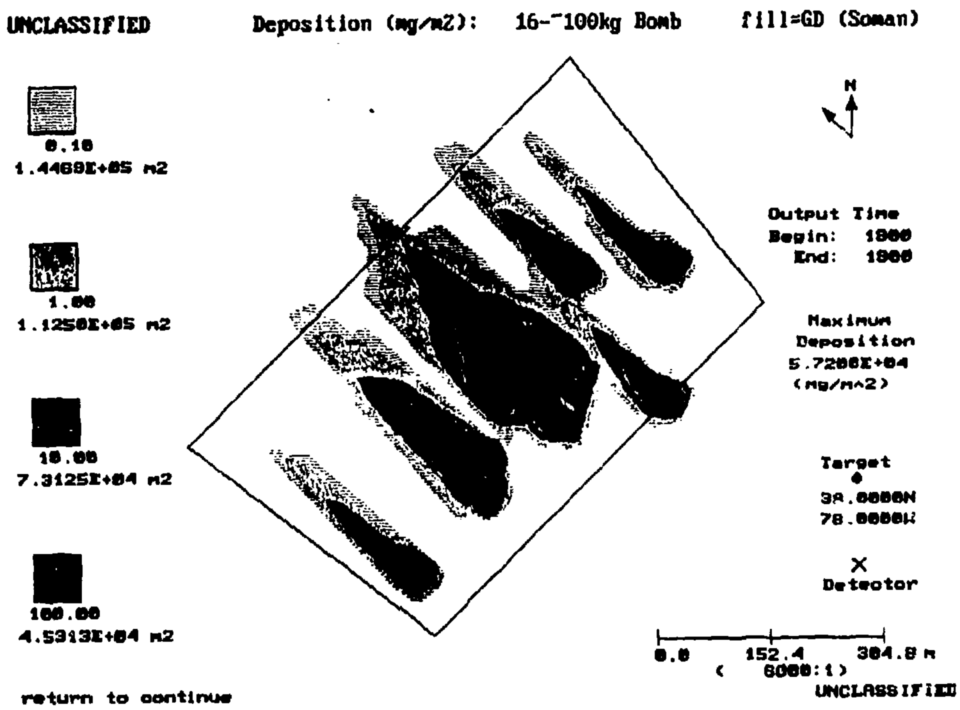
UNCLASSIFIED

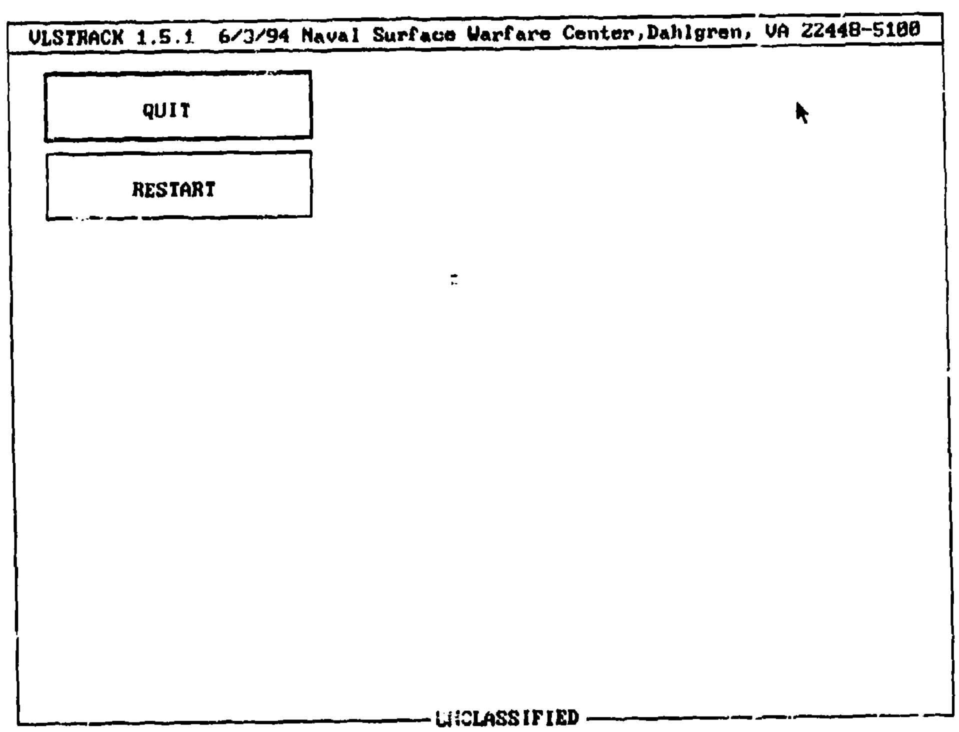

VLSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100
F1=help on item
MUNITION PROP. WINDOW
?=keyboard commands
CONTINUE
Number of Munitions
16
Rate of Fire
Simultaneous Bursts
Height of Release
10.0 m
Range
Low:
High:
ENTER=choose region
TAB=next column
SHIFT-TAB=previous col
PG-DN=next row
PG-UP=previous row
press any key to continue
UNCLASSIFIED

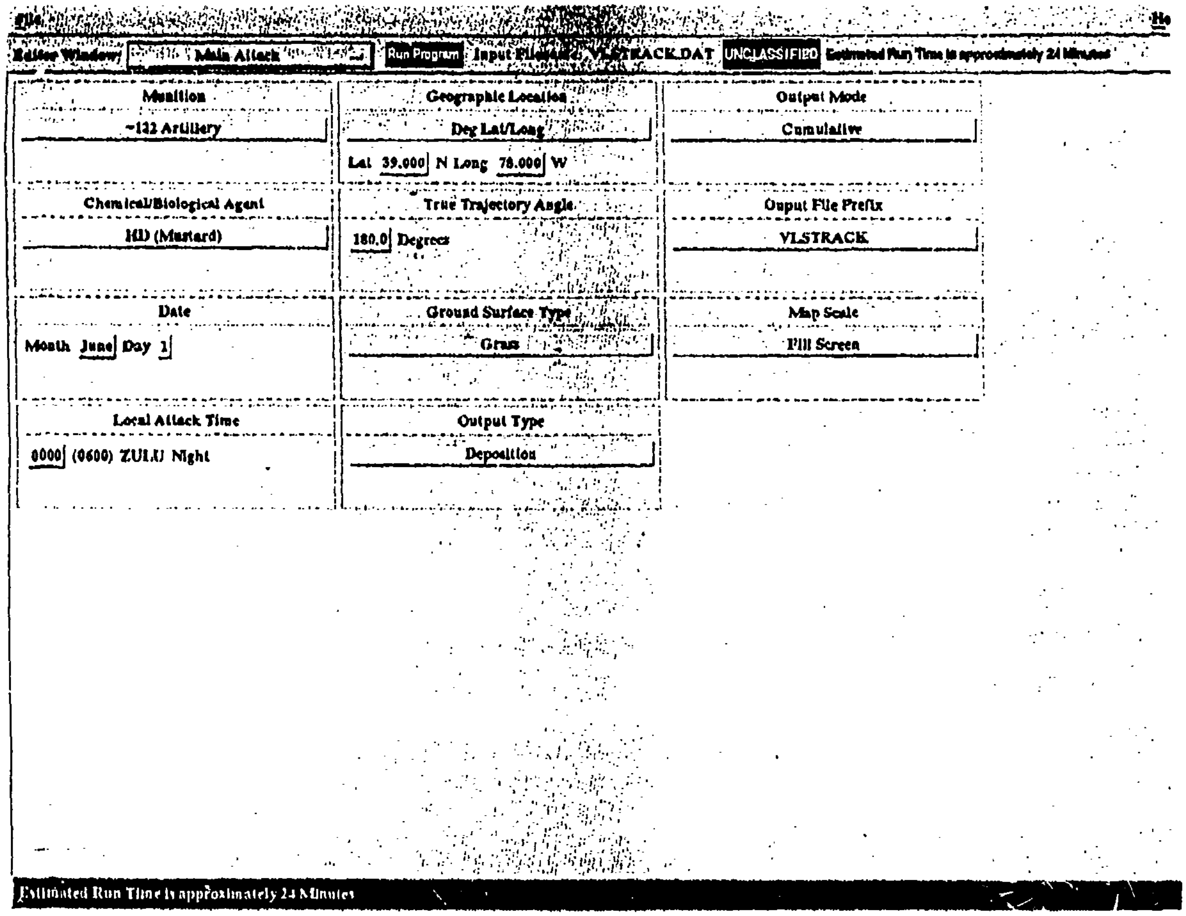

VLSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100
F1=help on item
ATTACK/MET. OPT WINDOW
?=keyboard commands
Detonation Coordinates
Gaussian
Met. Cond. Duration
1.0000 hrs
CONTINUE
Transition Times
Dawn: 0600 Day: 0800
Dusk: 1800 Night:2000
Meteorology Mode
Time Variable
Range
Low:
High:
Detector Alarm
Passive
Selections
Wind Measurement Ht.
5.0 m
Wind Dir. Sensitivity
+ or - 15.0 deg
UNCLASSIFIED


ULSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100
F1=help on item
OUTPUT/COMP OPT WINDOW
?=keyboard commands
# of Grid Points
61 by 41
CONTINUE
Grid Sizing
Self-Adjusting
Range
Low:
High:
Contours (mg/m2)
1st 100.00 2nd 10.00
3rd 1.00 4th 0.10
Random Number Seed
349875
Selections
Outputs/Met. Time Per.
1
Wind Meander Seed
863005
Plot Pause Mode
No Pause
UNCLASSIFIED

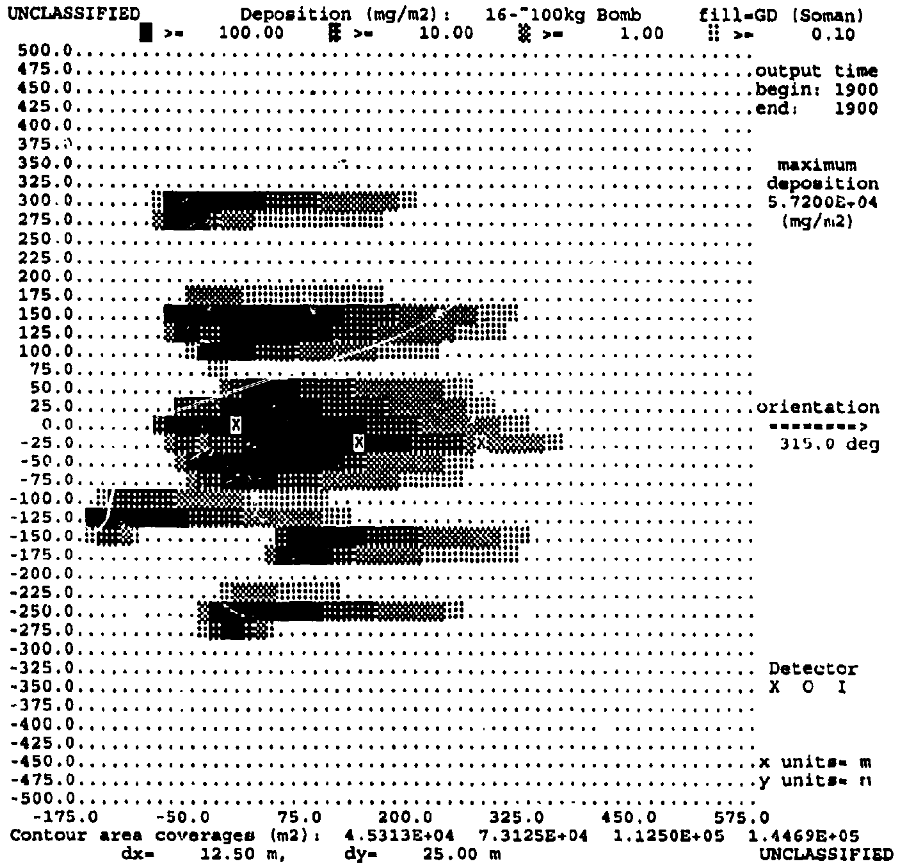

ULSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100
F1=help on item
DETECTOR WINDOW
?=keyboard commands
Detector File
CONTINUE
Detector Number
3 out of 3
Next Detector (new)
Detector Location
39.0020N 78.0020W
Previous Detector
Range
Low:
High:
Clear Detectors
And Continue
Detector Duration
60.0 min
Detector Threshold
0.0100 mg/m2
UNCLASSIFIED


UNCLASSIFIED
Deposition (mg/m2): 16-~100kg Bomb
fill=GD (Soman)
N
0.10
1.4469E+05 m2
1.00
1.1250E+05 m2
10.00
7.3125E+04 m2
100.00
4.5313E+04 m2
Output Time
Begin: 1000
End: 1000
Maximum
Deposition
5.7200E+04
(mg/m^2)
Target
38.0000N
78.0000W
Detector
0.0
152.4
304.8 m
(6000:1)
UNCLASSIFIED
return to continue


VLSTRACK 1.5.1 6/3/94 Naval Surface Warfare Center,Dahlgren, VA 22448-5100
QUIT
RESTART
UNCLASSIFIED




```
 MAIN ATTACK MENU                     UNCLASSIFIED
0-RUN PROGRAM (check all parameter values first)
1-munition= ~100kg Bomb
2-chem/bio agent= GD (Soman)
3-month= August
4-day=  2
5-local attack time= 1900
  time of day= dusk
6-geographic units= deg lat/long
7-attack latitude=   39.0000N
8-attack longitude=  78.0000W
9-true trajectory angle=  45.0 deg
10-ground surface type= grass
11-output type= deposition
12-output mode= cumulative
13-output file prefix= vlsexamp
14-map scale= fill screen
15-ATTACK/MET. OPTION MENU (options selected)
16-OUTPUT/COMP. OPTION MENU (options selected)
17-MUNITION PROPERTY MENU (defined)
18-METEOROLOGY MENU (not defined)
19-DETECTOR MENU (none defined)
20-RECORD INPUT FILE
21-END PROGRAM
enter number
```


UNCLASSIFIED
Deposition (mg/m2): 16-~100kg Bomb fill=GD (Soman)
>= 100.00 >= 10.00 >= 1.00 >= 0.10
output time
begin: 1900
end: 1900
maximum
deposition
5.7200E+04
(mg/m2)
orientation
315.0 deg
Detector
X O I
x units= m
y units= m
500.0
475.0
450.0
425.0
400.0
375.0
350.0
325.0
300.0
275.0
250.0
225.0
200.0
175.0
150.0
125.0
100.0
75.0
50.0
25.0
0.0
-25.0
-50.0
-75.0
-100.0
-125.0
-150.0
-175.0
-200.0
-225.0
-250.0
-275.0
-300.0
-325.0
-350.0
-375.0
-400.0
-425.0
-450.0
-475.0
-500.0
-175.0 -50.0 75.0 200.0 325.0 450.0 575.0
Contour area coverages (m2): 4.5313E+04 7.3125E+04 1.1250E+05 1.4469E+05
dx= 12.50 m, dy= 25.00 m
UNCLASSIFIED

CHEMICAL-BIOLOGICAL EFFECTS MODELING IN ARL

Mr. William J. Hughes

Acting Chief, Chemical-Biological and
Nuclear Effects Division
Survivability/Lethality Analysis Directorate
U.S. Army Research Laboratory
Aberdeen Proving Ground, MD

Intentionally Left Blank

Army Research Laboratory

Survivability/Lethality Analysis Directorate

Chemical-Biological And Nuclear Effects Division

- Provide Objective Vulnerability/Survivability And Effectiveness Analyses Of Chemical(Including Obscurants), Biological, And Nuclear Threats To Weapon Systems, And To The Individual Soldier
- Ensure That The Latest CB&N Survivability Technology Is Used In Developing Army/Services Systems
- Assist In The Design And Incorporation Of CB&N Characteristics In DoD Systems For Enhancing Their Survivability
- Serve As The Army/Services Focal Point For Technical Advice On CB&N Matters
- Develop And Maintain State-Of-The-Art Tools, Equipment, And Methodologies To Support CB&N VLS Analyses Of Weapon Systems And Personnel

Army Research Laboratory | Survivability/Lethality Analysis Directorate

Division Chief
William J. Hughes
(Acting)

Survivability & Modeling & Simulation
Drew Farenwald

Systems Survivability
John Bellhus

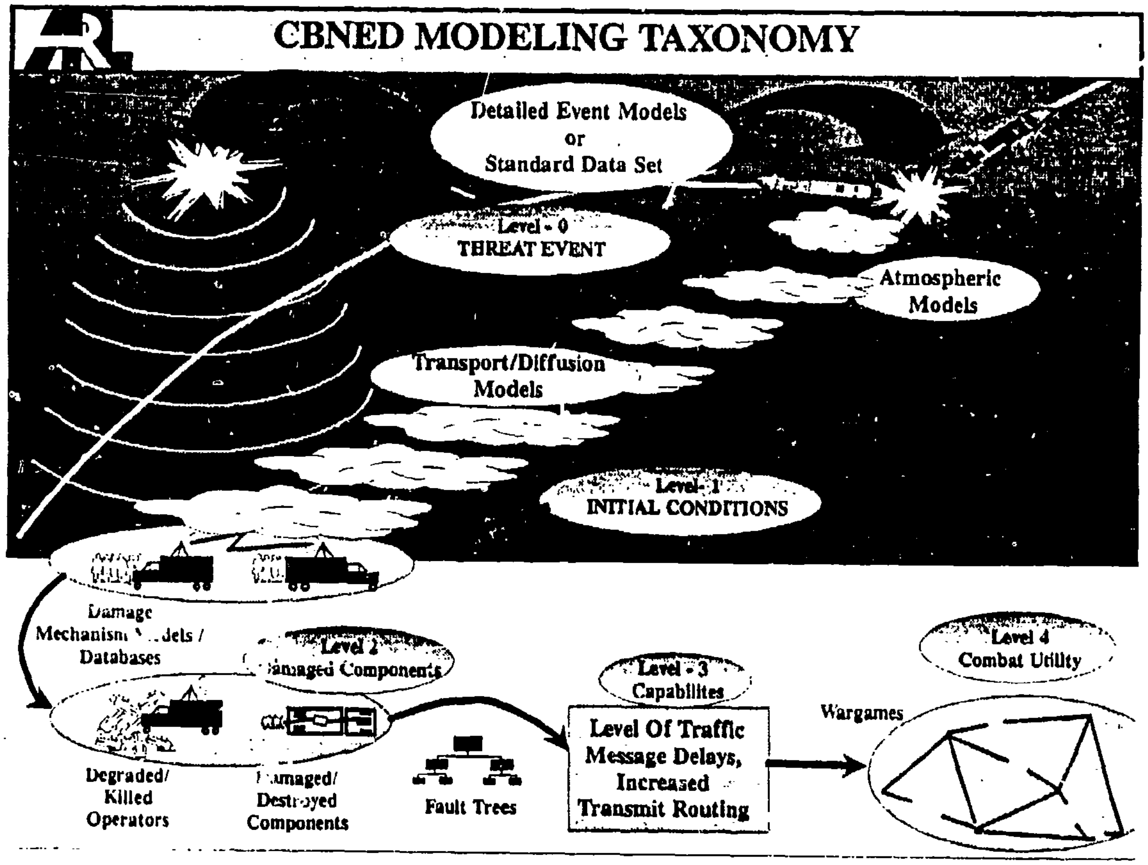
Threat Effects & Advanced Applications
Anthony Van De Wal

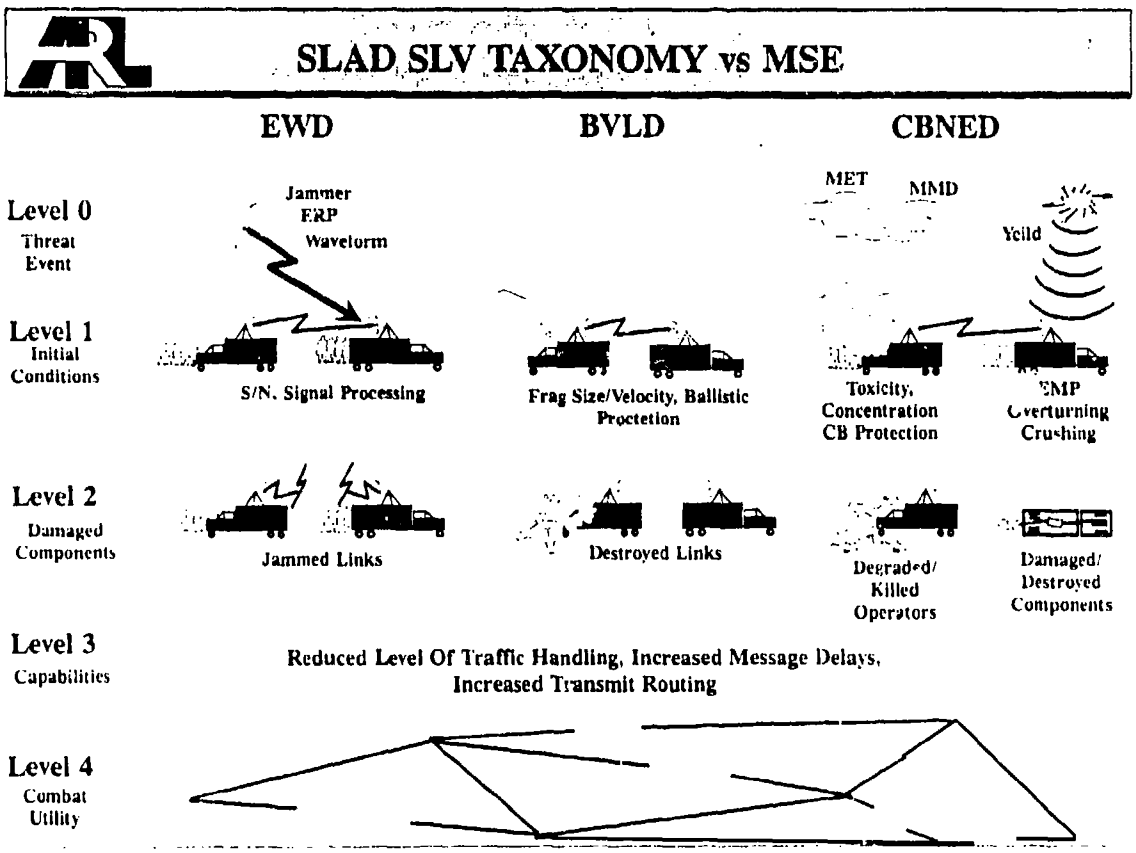
Slide # 4

Army Research Laboratory | Survivability/Lethality Analysis Directorate

Air Defense	Air Systems		Ground Systems	Munitions/Sensors	Soldier Vulnerability
THAAD	Comanche				SIPE
GBR					
Stinger					
PATRIOT					
GBS					
CORPS SAM					

Slide # 3


CBNED MODELING TAXONOMY
Detailed Event Models
or
Standard Data Set
Level - 0
THREAT EVENT
Atmospheric
Models
Transport/Diffusion
Models
Level - 1
INITIAL CONDITIONS
Damage
Mechanism Models /
Databases
Level 2
Damaged Components
Level - 3
Capabilities
Level 4
Combat Utility
Wargames
Level Of Traffic
Message Delays,
Increased
Transmit Routing
Degraded/
Killed
Operators
Damaged/
Destroyed
Components
Fault Trees


SLAD SLV TAXONOMY vs MSE
EWD
BVLD
CBNED
Level 0
Threat
Event
Jammer
ERP
Waveform
MET
MMD
Yeild
Level 1
Initial
Conditions
S/N, Signal Processing
Frag Size/Velocity, Ballistic
Proctetion
Toxicity,
Concentration
CB Protection
EMP
Overturning
Crushing
Level 2
Damaged
Components
Jammed Links
Destroyed Links
Degraded/
Killed
Operators
Damaged/
Destroyed
Components
Level 3
Capabilities
Reduced Level Of Traffic Handling, Increased Message Delays,
Increased Transmit Routing
Level 4
Combat
Utility

Intentionally Left Blank

OVERVIEW OF XM56 LARGE AREA SMOKE GENERATOR PROGRAM

Mr. Ray Malecki

XM56 Engineer
Office of the Product Manager
for Smoke/Obscurants
Aberdeen Proving Ground, MD

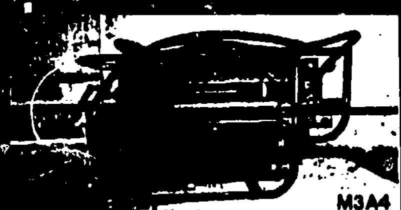
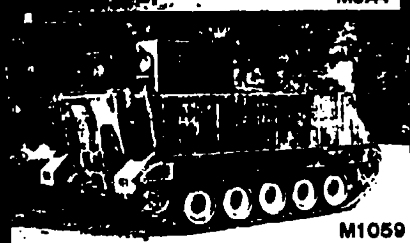
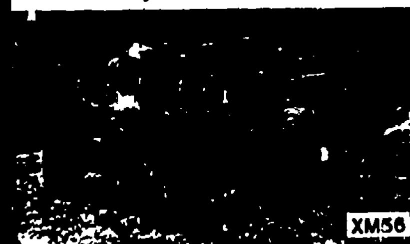
Intentionally Left Blank

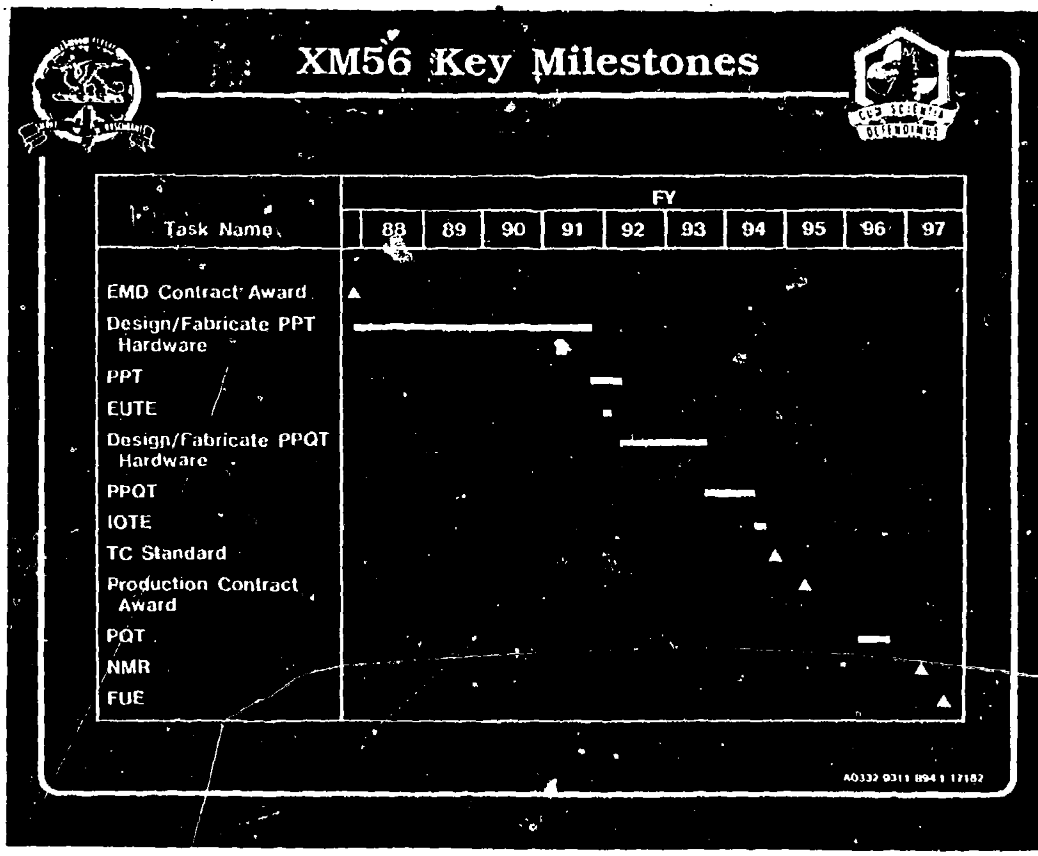
XM56 Smoke Generator System

DESCRIPTION:

- Modular design
- Gas turbine engine powered
- Visual screening
  - 1.33 gal/min fog oil
  - 1 hour operation
- Infrared screening
  - 10 lbs/min
  - 30 minutes operation
- 1 x 5 kilometer screen with 6 systems

System Comparisons

	Fuel	Visual	Infrared	Millimeter Wave
 M3A4	Mogas	X		
 M1059	Mogas	X		
 XM56	Diesel, JP4, 5, or 8	X	X	X (P3I)


XM56 Key Milestones
FY
Task Name
88
89
90
91
92
93
94
95
96
97
EMD Contract Award
Design/Fabricate PPT Hardware
PPT
EUTE
Design/Fabricate PPQT Hardware
PPQT
IOTE
TC Standard
Production Contract Award
PQT
NMR
FUE

XM56 NBCCS PROGRAM & APPLICATION OF TEST RESULTS

Ms. Kathleen M. Considine

Project Engineer
Chamberlain MRC Corporation
Hunt Valley, MD

Intentionally Left Blank

XM56 NBCCS Program and Application of Test Results

Kathleen M. Considine
Chamberlain MRC

Presentation Topics

- NBCCS Program Overview
- Functional Component Testing
- Test Results
- Impact on Technical Data Package (TDP)
- Future Research Areas

XM56 NBCCS
Program Overview

Program conducted with Calspan Corp., Buffalo, NY

1. Employ NBCCS design guidelines
2. Identify Mission Essential Components
3. Define/Assign Exposure Codes
4. Reference available data
5. Develop/conduct surety test
6. Apply results to Final Design and TDP

XM56 NBCCS
Contract Deliverables

Program Plan

Test Plans

Test Reports

Design Parameters Report

Assurance Plan

Maintenance Plan

Final Report

Component Testing

All tests performed at Calspan Corporation's facilities

- XM56 System components
- Housing/mounting of electrical components tested
- Tested in triplicate
- Established operational parameters

Test Results Incorporated in Design

- Design Parameters Report identifies design enhancements incorporated and improvements to be implemented
- Original design of Main Control Panel retained
- Specify protective boot over switches to improve sealing
- Plug socket heads on exposed lifting rings to eliminate collection point

Test Results Incorporated in Design

- Incorporate DCNS tubing/adhesive assembly process to all harnesses
- Incorporate pressure test for acceptance of panel lights

Impact on TDP Drawing Package

Addition of note to "flag" items or features which incorporate NBCCS:

"This (item, feature, material) has been (tested, evaluated) for NBCCS. Any modification to this feature may impact the System's Survivability, as designed."

Impact on TDP Drawing Package

Applied to:

- Gaskets (tested mounting configurations and material)
- HDPE components (Fog Oil and Fuel Tanks; Hopper and Lid)
- Cable tubing and adhesives
- Fog Oil Pump/Motor
- Finish notes - Anodic Coating
- Airtight, watertight test specification notes

Impact on TDP Assurance Plan

<u>Assurance Plan</u>

Important features identified with assurance vehicle

Example:

	Item/Subcomponent /Material	NBC Parameter	Assurance Vehicle
1	HDPE	Material Compliance	Certification to ASTM D1248
2	Motor Controller Assy.	Sealed Unit	Certification of spray tight test to MIL-STD

Impact on TDP Maintenance Plan

Maintenance Plan

Direct impact on System Maintenance Manuals by specifying Preventive Maintenance Procedures and Decontaminations Instructions (remove, replace tasks)

Example:

Part Description	Rec. interval	Maint. Procedure
Knobs (MS91528-2T2B)	Following chemical attack, after decon.,	Remove, discard and replace as part of decon. procedure. Info. included in TM 3-1040...

XM56 NBCCS Final Report

(Draft submittal June 1994)
Executive Summaries of:

- Program Plan
- Material Screening Test Plan and Results
- Component Test Plan and Results

NBCCS
Future Research

- Increase material and component testing
- Expand material and component database
- Integration of Military Parts Control Systems (MPCAG, etc.) with available material and component data

Chamberlain MRC
NBCCS Point of Contact:

Kathleen M. Considine
Project Engineer
Chamberlain MRC
336 Clubhouse Road
Hunt Valley, MD 21031
Phone 410-527-7527
FAX 420-771-9088

Intentionally Left Blank

CHEMICAL RESISTANCE TEST PROGRAM FOR SELECTION/DESELECTION OF MATERIALS

Mr. Wendel J. Shuely

Research Chemist
U.S. Army Edgewood Research,
Development, and Engineering Center
Aberdeen Proving Ground, MD

Intentionally Left Blank

TEST METHODOLOGY FOR CHEMICAL RESISTANCE OF MATERIALS

Wendel Shuely

U.S. Army Edgewood Research, Development and Engineering Center
Aberdeen Proving Ground (EA), MD

OUTLINE

- Integrated Material Selection for NBCCS Chemical-Material Compatibility
- Predictive and Experimental Methodology
- Interface and Planning
- Summary

BACKGROUND REPORTS ON MATERIALS SELECTION
FOR NBC CONTAMINATION SURVIVABILITY

Shuely, Wendel J. and McNeely, James J., Material Selection Guide Derived from a Material-Chemical Compatability Database: Feasibility Based on Database and Predictive Model Evaluation, CRDEC-TR-397, September 1992, NTIS No. ADA 266058.

Shuely, Wendel J., "Integration of Test Methodology, Material Database, and Material Selection/Deselection Strategies for a Chemical-Material Compatibility System" in Proceedings of the Fourth International Symposium on the Computerization and Use of Materials Property Data, NIST/ASTM, Gaithersburg, MD, October 1993.

Shuely, Wendel J., "Test Methodology for Development of Corrosion Resistant Polymeric Materials: Predictive and Experimental Methods for Chemical Resistance Screening" in Proceedings of the 12th Biennial Symposium on Managing Corrosion with Plastics. November 1993.

Shuely, Wendel J. and Ince, B.S., "Thermogravimetric Method for Measurements of Equilibrium and Transport Properties Relevant to Chemical-Polymer Compatibility Evaluation" in the Proceedings of the 22nd Conference of NATAS, p 254-259, September 1993.

Shuely, Wendel J., Predictive Methodology for Evaluating the Interaction of Polymeric Materials with Chemicals Based on Computer-Stored Phase Diagrams, in Proceedings of the Scientific Conference on Chemical Defense Research, November 1993. CRDEC-SP.

Shuely, Wendel J., Experimental Methodology for Evaluating Polymer-Chemical Interaction Based on a Polymer Solubility Determination in Proceeding of the Scientific Conference on Chemical Defense Research, November 1993. CRDEC-SP.

Integrated Material Selection for NBCCS Chemical-Material Compatibility

Overview

- OBJECTIVE: Integrate Database to Test Methods
- METHODOLOGY:
  - Design Specifications
  - Criteria For Test Methods
- RESULTS: Top Down - Mainframe Chemical-Material Database with File Transfers from PC Test Report Databases

Objectives

- GIVEN a database of historical chemical-material test property data that functions at the simple retrieval level, convert/enhance/evolve the database to search, compare, sort, and rank materials for chemical resistance
- DEVELOP test methods integrated to the database
- REEVALUATE historical data sets with respect to relaxation of search parameters for compatibility with the new standardized test methods

Methodology Rationale

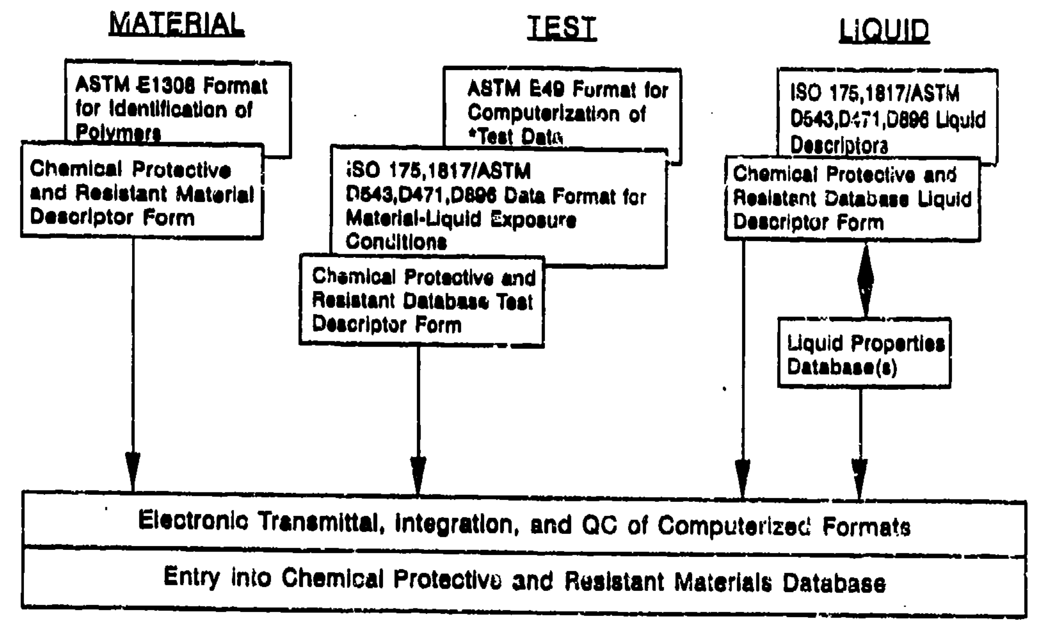
- Numerical Data (Not Bibliographic)
- Absolute Values (Not Relative/Ratio)
- No Classification Judgements (i.e., Good, Poor)
- Increased Standardization to Support Search, Compare, Sort, and Rank Strategies

Methodology Rationale (contd)

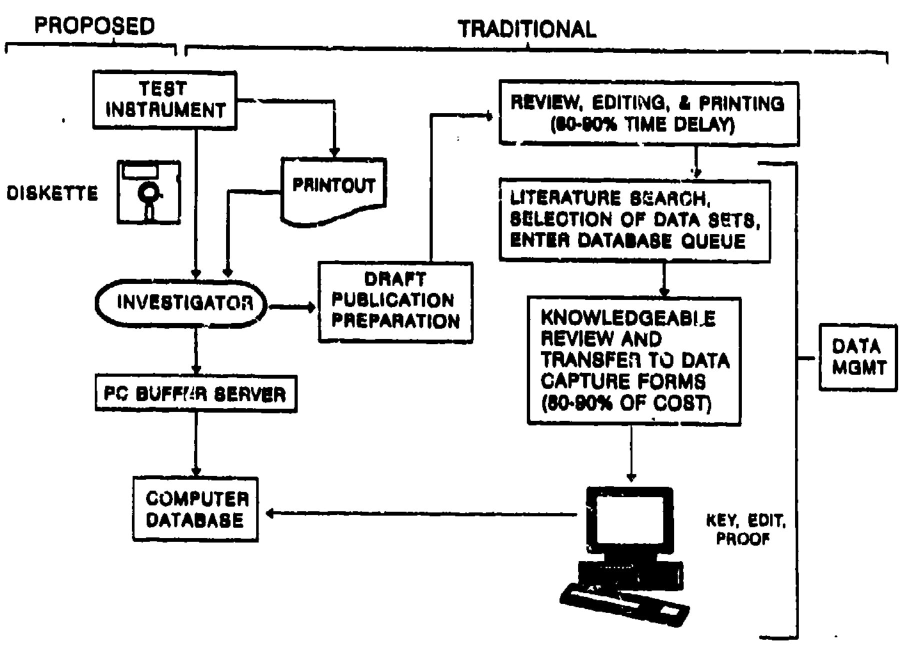
- Emphasis on equilibrium properties (vs. transient) for single chemical-polymer pairs at single exposure time-temperature pairs to prevent data obsolescence due to changes or evolution of chemical formulations, exposure times, temperature profiles, etc.
- Strategy for partially filled database with missing data by progressive relaxation of search boundaries

(Reference: Shuely, W.J. and McNeely, J.J., Material Selection Guide Derived from Material-Chemical Compatibility Database: Feasibility Based on Database and Predictive Model Evaluation, CRDEC TR 397, September 1992, NTIS No. ADA 266058)

Computerized Format Modules for Documentation of Liquid Effects on Material Properties



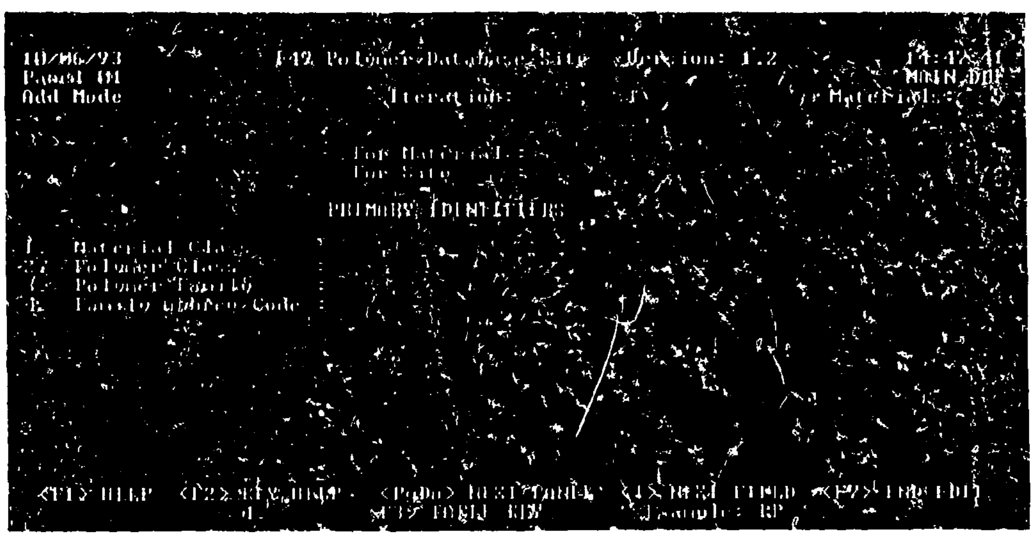
Direct Test-to-Database



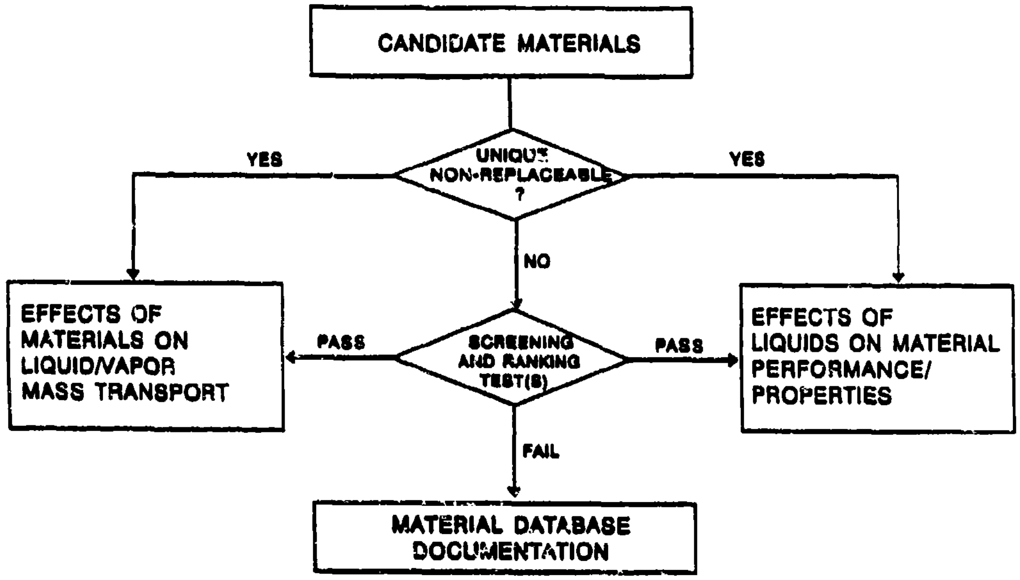
ASTM E 49 Formats for Identification of Polymeric Materials and Formats for Recording Data Generated by Standard Tests.

ASTM E 49 Format for:	Hard copy	dBase IV Screen Forms	Menu: alpha site	Menu: beta site, in-house	Menu: beta site, external
E 1308, Identification of Polymers in Computerized Database			✓complete	✓complete	
ASTM D 3132, Test Report, Polymer Solubility	✓	✓			
ASTM D 471, Test Report, Elastomer: Equilibrium Solubility, Desorption Diffusion Coefficient, Fraction Extracted	✓	Part A, dBase IV Part B, (C-Program)			
ASTM D 543, Test Report, Thermoplastic: Equilibrium Solubility, Desorption Diffusion Coefficient, Fraction Extracted	✓				
ASTM D 543/D 471, Test Report, Mechanical Specimen Chemical Exposure	✓				
ASTM D 638/D 412, Test Report, Tensile		✓(D 638)			

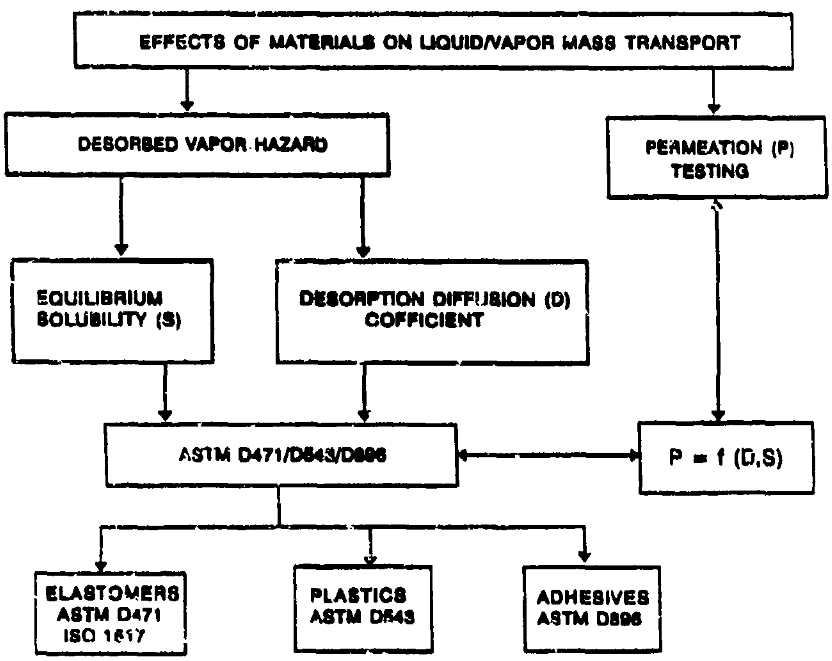
Panel 1, E 49/E 1308 Polymer Database



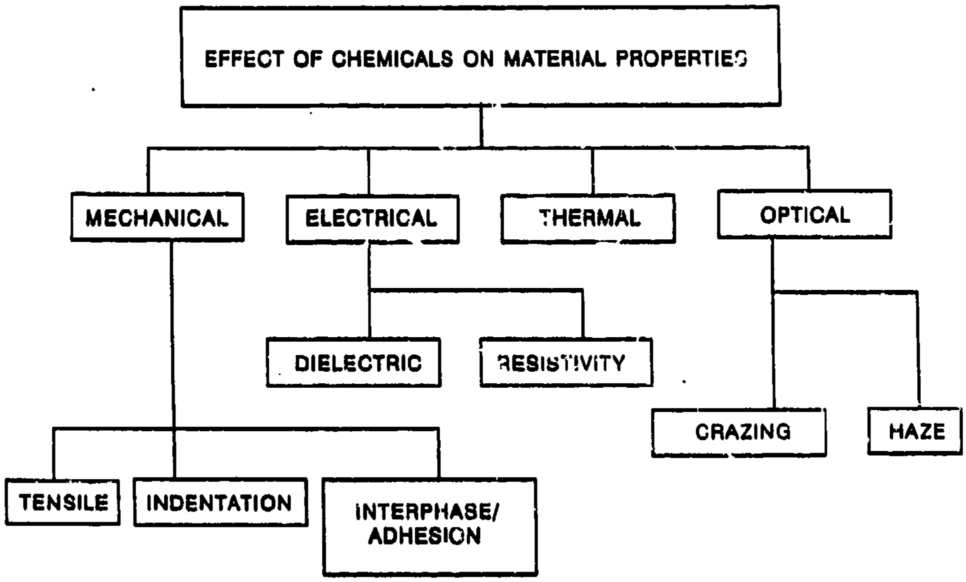
Material Test Development Strategy: Initial Screening Test



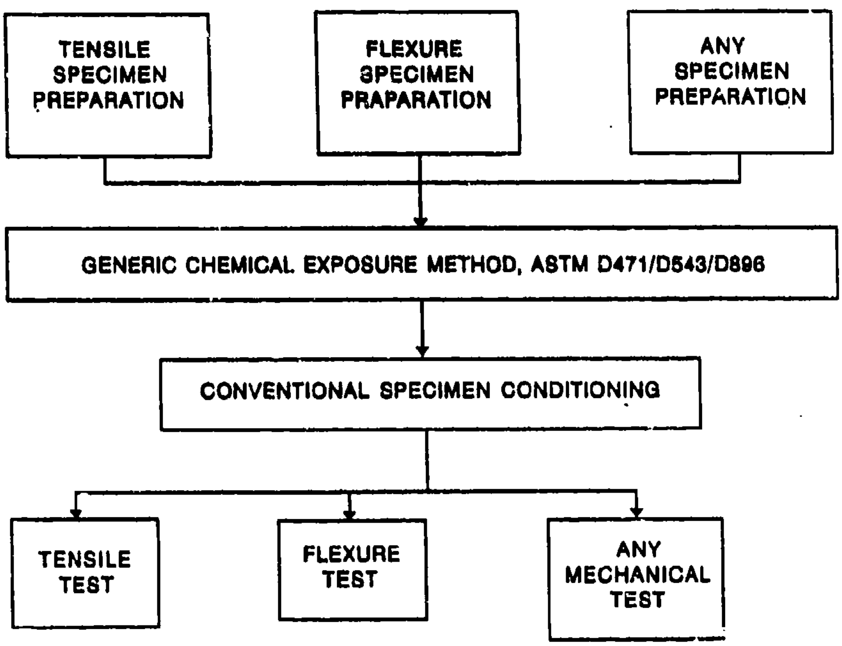
MTD Strategy: Effects of Materials on Liquid/Vapor Mass Transport



MTD Strategy: Effect of Chemicals on Material Properties



Scheme for Use of a Generic Chemical Exposure Method with Any Test



Predictive and Experimental Methodology for NBCCS Material Selection

PROCEDURES

- Experimental Polymer Solubility
- Predictive Polymer Interaction
  - Rationale Based on Phase Diagrams
    - Volume-Fraction vs Temperature
    - Polymer Solubility Phase Diagrams
      - 2-Parameter
      - 3-Parameter
- Systems: Software and Hardware

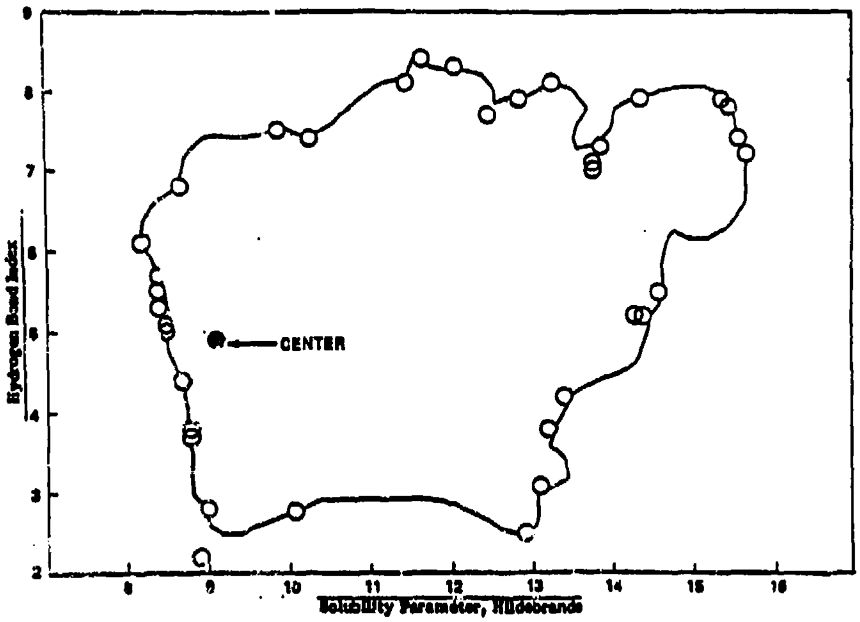


Figure 2. Example of a Polymer Solubility Phase Diagram for Screening of Material-Liquid Compatibility: Poly[(methyl methacrylate)-*co*-ethylacrylate-*co*-butylacrylate]

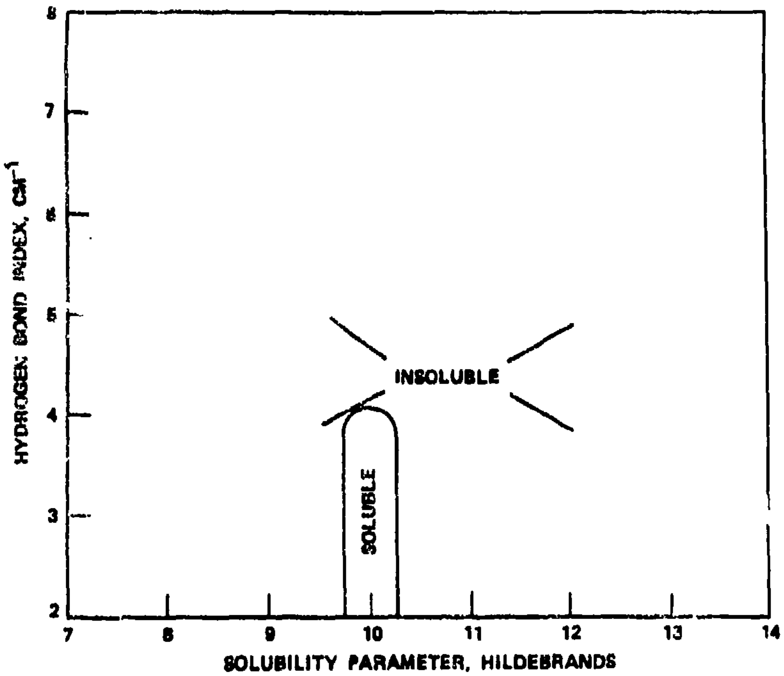


FIGURE . POLYMER SOLUBILITY PHASE DIAGRAM OF A POLYURETHANE[16]

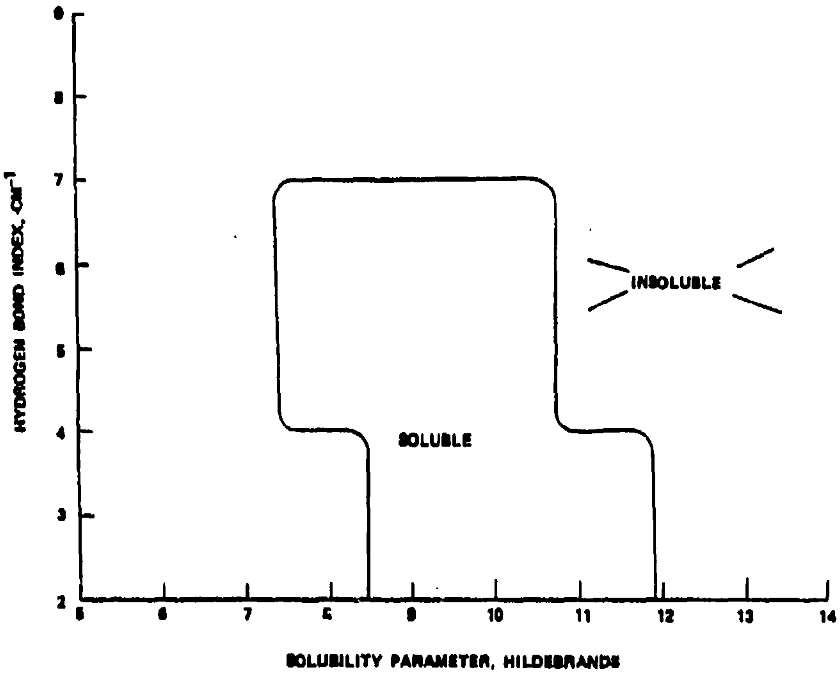


Figure . Polymer Solubility Phase Diagram, Two Parameter System: Styrenated Polyester (Alkyd).

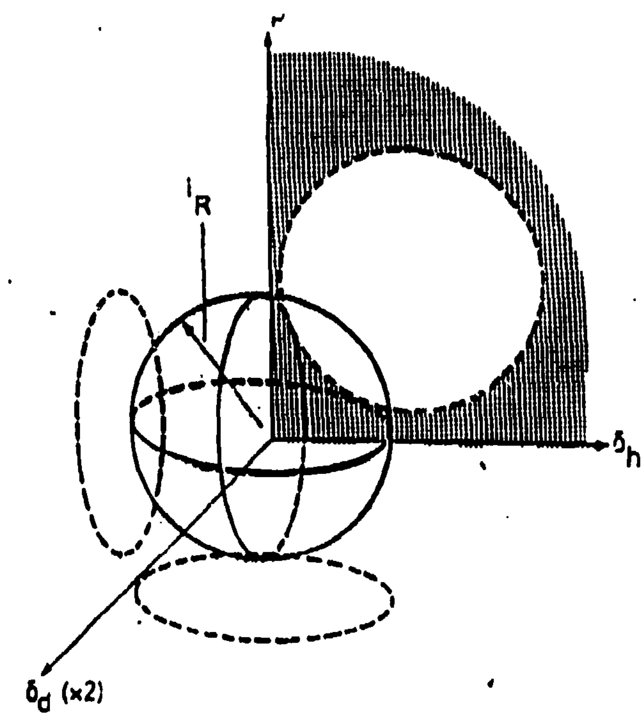
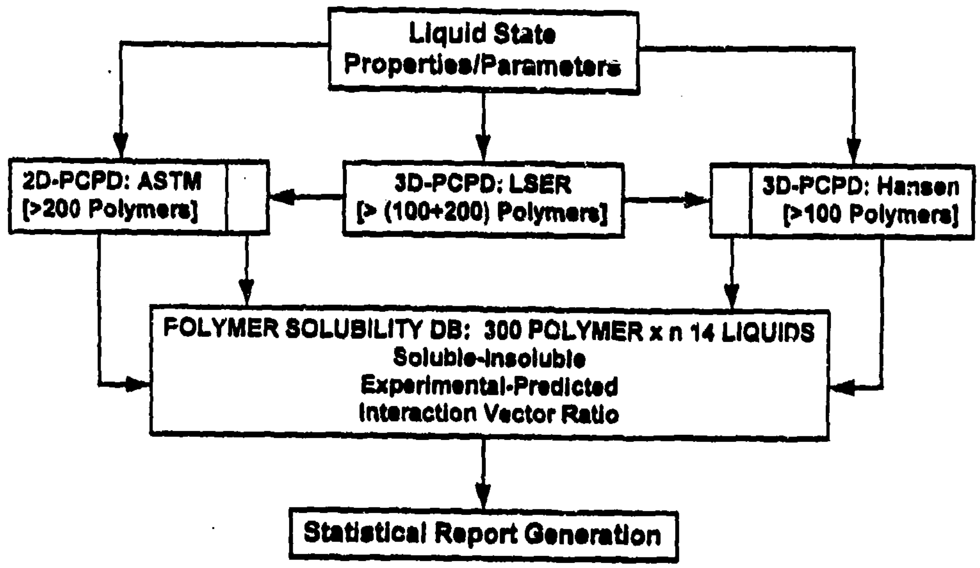
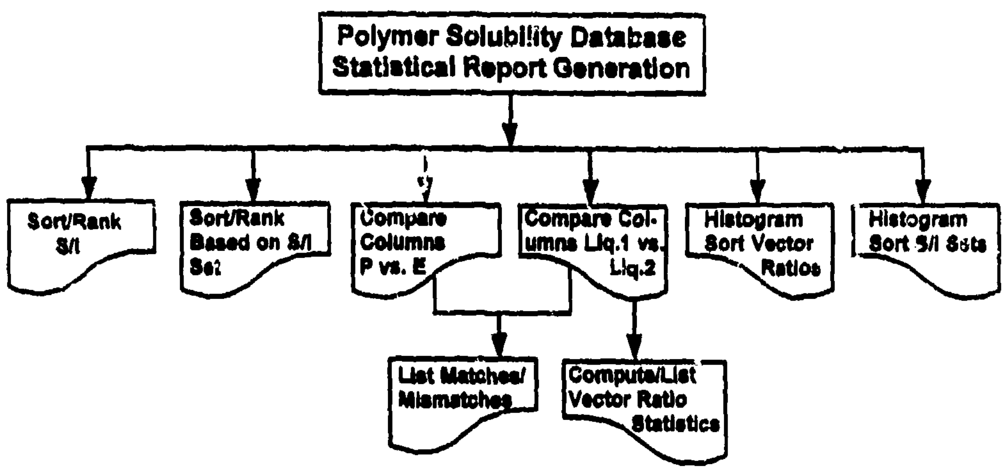


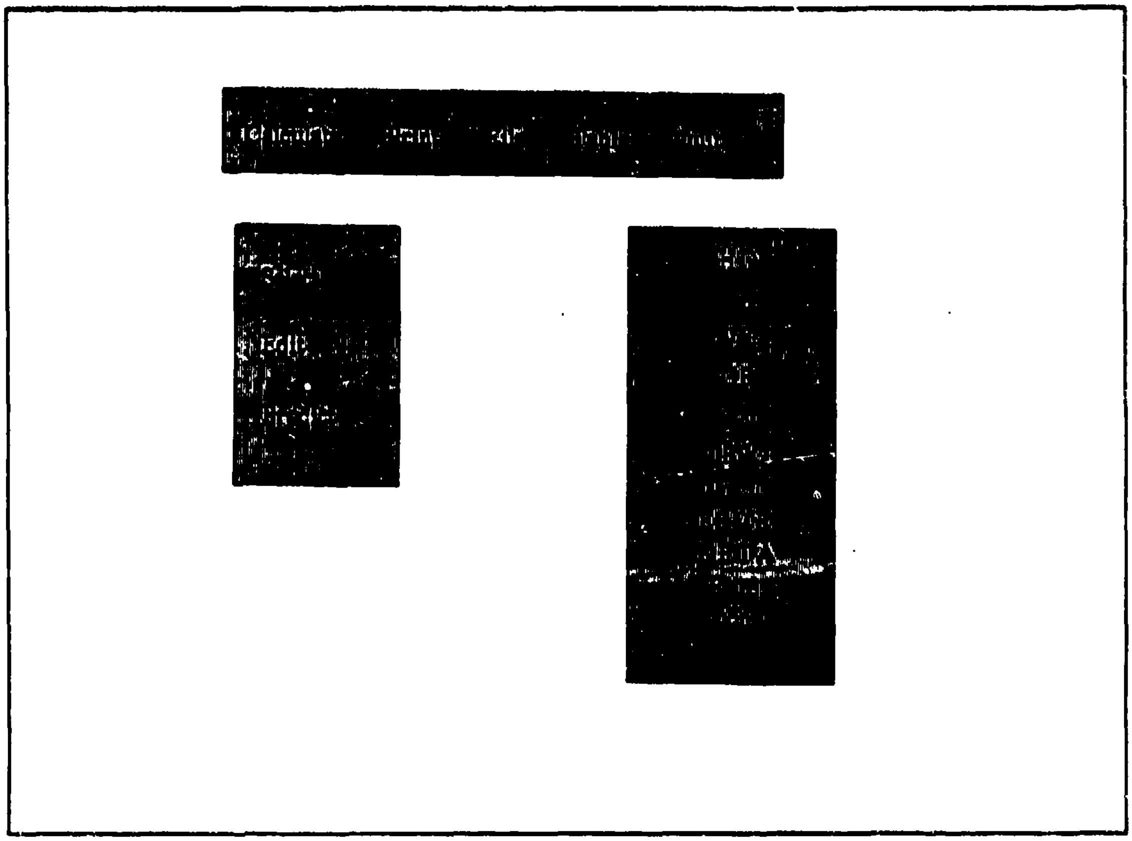
FIGURE 1. Representation of a Hansen parameter solubility sphere

Flow Chart of Polymer-Liquid Solubility Databases Based on Polymer Cohesion Parameter Diagrams (ASTM D 3132): Predictions



Flow Chart of Polymer-Liquid Solubility Databases Based on Polymer Cohesion Parameter Diagrams (ASTM D 3132): Statistical Report Generation





Calculate Print File Table Quit

Parameters
Statistics
Prediction
PRINT TO SCREEN
PRINT TO HPJET II OR III
PRINT TO PANASONIC
PRINT TO EPSON
GENERIC PRINTER
PRINT TO FILE
Solubility-by ave ratio
Solubility-by class
Solubility-highest/lowest
Solubility-class fractions
P/E Comparison-by liquid
P/E Comparison-incorrect
P/E Comparison-sol by class
Current status tables
Liquid to Liquid
Unalike Predictions

RESULTS

Chemical-Polymer Interaction from Computer-Stored Phase Diagrams

Two-Parameter Predictive Method

Three-Parameter Predictive Method

Distribution Analysis of Interaction Vectors

Predictions for Resistance with Several Chemicals

Predictions for Concurrent Resistance with Multiple Chemicals by Logically .ANDED. Searches

Generalized Differential Solvent Parameter Analysis

Table 3. Interaction Prediction for: DIETHYLENE TRIAMINE (Computer Printout, Truncated) DS: 16.80 PS: 13.30 HS: 14.30

Chemical Resistance Rank	Vector Ratio	Polymer
1	3.86	Polyethylene, chlorosulfonated (Hypalon 20)
2	3.05	Polyethylene, chlorosulfonated (Hypalon 30)
3	2.98	Poly(tetrafluoroethylene) (Teflon SL2)
4	2.51	Poly(vinylchloride) (Vipla KR)
113	0.44	Poly(ethylene terephthalate) 8% OH (Desmophen 651)
114	0.43	Methylated melamine (Dynomin MM9)

Table 2. Polymer Composition versus Chemical Interaction Vector Ratio by 2-Parameter Predictive Method: and/or Experimental Solubility Classification by 2-Parameter Predictive Method: Computer Printout. Page 1, for 5 Chemicals (Truncated)

Liquid	TBPO	MeCl	EGME	DETA	F113
Polymer Class Name	Ratio P/E	Ratio P/E	Ratio P/E	Ratio P/E	Ratio P/E
AC Acryloid B-66 (MMA/BMA copolymer)	0.52 S	1.15 I	>1 NR I	>1 NR I	2.02 I
AC Acryloid B-72 (EMA/MA copolymer)	1.03 S	1.09 I	>1 NR I	>1 NR I	1.63 I
AC Acryloid B-82 (EA/MMA copolymer)	1.03 S	1.15 I	>1 NR I	>1 NR I	2.02 I
AC Acryloid K120N	0.85 S	1.09 I	>1 NR I	>1 NR I	1.63 I
AC Poly(butyl acrylate)	0.38 S	0.54 S	0.24 S	0.94 S	0.93 S
AC Poly(isobutyl methacrylate)	0.52 S	1.15 I	1.10 I	2.28 I	2.02 I
AC Poly(n-butyl methacrylate)	0.15 S	0.50 S	1.10 I	2.28 I	1.11 I
AC Poly(ethyl methacrylate)	0.63 S	1.15 I	1.10 I	2.28 I	2.02 I
AC Poly(methacrylic acid)	>1 NR I	>1 NR I	2.35 I	1.11 I	>1 NR I

Table 5. Polymer Compositions Versus Chemical Interaction Vector Ratio and Predicted (P) and Experimental (E) Solubility for a Set of Several Chemicals (Computer Printout Excerpt)

	Chemical	HD			GB			VX			GF			GD		
	(Solubility, Hydrogen Bonding Parameters)	(21.2, P)			(18.6, M)			(18.1, M)			(20.6, M)			(17.4, M)		
	Polymer	Ratio	P	E	Ratio	P	E	Ratio	P	E	Ratio	P	E	Ratio	P	E
CE	Ethyl Cellulose, N-22	0.51	S		0.06	S		0.17	S	S	0.40	S		0.29	S	
CE	Ethyl Cellulose, T-10	2.80	I		0.17	S		0.02	S		0.95	S		0.22	S	
CE	Ethyl Hydroxy-ethyl Cellulose	0.96	S		0.18	S		0.35	S	I	0.47	S		0.51	S	
CE	Nitro-cellulose, RS, 25 cps.	1.91	I		0.66	S		0.72	S	S	0.43	S		0.77	S	
CE	Nitro-cellulose, SS, 0.5 sec.	1.91	I		0.66	S		0.72	S		0.43	S		0.77	S	
EP	Epon E-72	0.77	S		0.27	S		0.12	S		0.89	S		0.04	S	
EP	Epon 812	0.23	S		0.66	S		0.72	S		0.43	S		0.77	S	
EP	Epon 864	0.46	S		0.84	S		0.91	S		0.59	S		0.97	S	

Table 6. Scaling and Ranking of Chemical Resistance Based on Logically "ANDED" Predictions of Solubility/Insolubility for Five Hazardous Liquids and Several Hundred Polymeric Materials (Computer Printout Excerpt)

Polymer	Polymer Class	Qty of Insolubles	Qty of Solubles	Average Ratio
40% Adipic, Glycerol Phthalate	AR	5	0	1.476
Cellulose Acetate, LL-1	CE	4	1	1.476
Diethylene Glycol Phthalate	NP	5	0	1.476
Saran F-220 (Poly(vinylidene chloride))	VI	4	1	1.538
Triethylene Glycol Maleate	NP	5	0	1.612
75 Isobornyl MA/25 C	AC	4	1	1.738
Lexan 100 Polycarbonate Resin	MI	3	2	1.744
Lexan 105 Polycarbonate Resin	MI	3	2	1.744
Soluble Mylars (EG-Terephthalate-49002)	ES	3	2	1.744
Versamid 100	AM	2	3	1.753

INTERFACE AND PLANNING

- Test Methodology Sub-Group of NBCCS TWG
- Future Test Method Development
- Enhancement of the Chemical Defense Materials Database
- Completion and Transition of Current NBCCS Test Methods

NBCCS TWG TEST METHODOLOGY SUBGROUP ACTIVITIES

Reviewed Progress and Status at NBCCS TWG Meetings

Voted to accept 7 methods for final development (4-0: ERDEC, ARL/MD, NATICK, DPG)

Distributed a summary of progress and status to CSM lab members and updated subgroup membership

1994 NBCCS WORKSHOP

- Previous 1992 and 1993 Workshops Transitioned Results and Methods to Chemical Surety Material (CSM) Labs
- 1994 Workshop will emphasize planning to apply the material selection and test methods to several typical NBCCS material selection exercises that will be ongoing in 1995.
- Attendees will be selected based on feasibility of collaborative projects in 1995 determined through a survey
- September 1994 at ERDEC

CANDIDATE MATERIAL-COMPONENT CORRELATION FOR A POLYMER-CHEMICAL COMPATIBILITY TEST PROGRAM: NBCCS DECONTAMINABILITY CRITERION

- Material Selection/Deselection Screening Tests
- Immersion Sorption/Desorption ASTM D471/D543
- Droplet Weathering/Desorption
- Decontaminability Cell: one-sided permeation cell or decontamination cell
- Chamber/Wind Tunnel Panel Tests
- TOP 8-2-111 NBCCS Small Items

CHEMICAL-MATERIAL COMPATIBILITY TEST METHODS FOR IMMEDIATE DEVELOPMENT

ELECTRICAL

ASTM D 3638 (INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC 112)
Comparative Wet Tracking Index, surface electrical tracking for liquid surfaces wetted by contamination or condensation on electronics or dielectrics. Ammonium chloride can be substituted with DS2 and/or HF acid spiked phosphates.

THERMOCHEMICAL/THERMOMECHANICAL TESTS

ASTM/ISO Micro thermal-mechanical tests under development within DoD composite aerospace workgroups

CANDIDATE CONCEPTS FOR CHEMICAL-MATERIAL COMPATIBILITY TEST METHODOLOGY FOR NBCCS

	FEASIBILITY	
CONCEPT	MODELING	TEST METHODOLOGY
Material Operating Limit	High to Moderate	Yes
Plasticization	Feasible	Yes
Permeation/solubility/ diffusion correlations	Feasible	Yes
Commercial Model Chemicals	Statistical	Yes

THE PREDICTIVE METHOD RESEARCH PLAN

Complete publication for DoD versions of predictive methods for agent-polymer interactions.

Convert material documentation of 300+ polymers from the vague mainframe format to ASTM E1308 format (the industry standard).

Complete the first phase for the integrated computational database for chemical-polymer interaction predictions with the assistance of database programmers.

Compare predictive vs experimental results and provide guidelines on use of predictive methods.

Initiate development of predictive methods for mixtures, e.g. DS2 and related decontamination solutions.

Draft generic SOW for NBCCS program use of predictive methods and results in material screening and deselection.

THE RESEARCH PLAN FOR EXPERIMENTAL SCREENING METHODOLOGY

Draft and publish "Unlimited" and DoD only versions of the rationale for screening test methodology.

Submit the ASTM D3132 draft to ASTM.

Obtain feedback from collaborative labs on the use of 1 ml specimen volumes for hazardous liquids.

Add additional control specimens to cover a few missing observation code classes.

Submit the computerized test report to the CBIAC to implement direct file transfer of test results.

Obtain feedback from other dbase4 Test Report users and revise formats as needed.

Obtain feedback from oga researchers on solubility observation codes and revise as needed.

Draft a generic SOW for including screening in a NBCCS material test program.

Systematic Strategy for a Materials Science Approach to Enhancing the Capabilities of a Materials Database

- Programmed Self-Inventory
  - Occurrence/Nonoccurrence of Data
  - Tally Functions
- Programmed Self-Critique
  - Deviation from Standard Test Parameters
  - Material Specimen Documentation
  - Test Versus Property Identifier
  - Disclaimers, Warnings

Systematic Strategy for a Materials Science Approach to Enhancing the Capabilities of a Materials Database (cont)

- Programmed Self-Evaluation
  - Define Equivalence/Nonequivalence
  - Trends
- New Search Strategies
  - Material Selection
  - Material Ranking
  - Material Benchmark Sorting

SUMMARY

- An inter-related scheme of NBCCS test methods has been designed and integrated into a chemical-material compatibility database.
- A polymer solubility test successfully screens out or deselects most nonresistant polymeric materials.
- The candidate resistant materials are submitted to further testing, either for the effect of chemicals on materials or the effect of the material on chemical transport in/around/through the polymer.
- A computerized test report has been developed and linked to an ASTM E 1308 file to document the material test specimen.
- These PC database reports can then be merged and transmitted to the mainframe materials database to provide a direct paperless transfer mechanism.

PREDICTIVE METHODOLOGY FOR RANKING CHEMICALLY RESISTANT MATERIALS

The rationale for the predictive methods was documented in NACE, NATAS, and NIST publications.

The format was finalized for documenting the predictive results in the mainframe Chemical Defense database. Over 1500 predictions were transferred to the CBIAC PC buffer for the mainframe (5 agents x >300 polymers).

Collaborated with CBIAC on documentation of manufacturers, copolymer content, ASTM codes, and other material documentation data for the mainframe for each of the 300+ polymeric materials in the predictions.

A comprehensive plan was designed for integrating the disconnected code to produce a modular computational database system for chemical-polymer interaction predictions.

EXPERIMENTAL METHODOLOGY FOR SCREENING MATERIALS FOR NBCCS CHEMICAL RESISTANCE: ASTM D3132

The rationale for screening tests in an integrated test scheme was developed and published.

The minimization of test liquid volume and manipulation was tested with over 30 specimens and specific liquid volumes and test intervals were standardized.

ASTM D3132 was rewritten to add the objective for screening for nonsolvents, i.e. chemically resistant polymer-liquid pairs.

Several sources of standard control materials were procured and stockpiled as test controls; 4 were commercial sources and 2 were NIST SRM sources (polystyrene and polyisobutylene).

An NBCCS Chemical Resistance Screening Test Report (ASTM D 3132) was computerized on dbase4; a Summary Test Report was extracted for file transfer to the Chem Defense Database.

Solubility observation comparisons from independent determinations were completed for over 20 specimens. Further test validation studies were arranged with OGA/commercial labs.

A plan for transition of this method to Chemical Surety Material (CSM) labs was revised to include stipulation that only storage fume hoods be used, based on feedback obtained at ARL sponsored workshops.

A NBCCS DECONTAMINABILITY TEST METHOD HAS BEEN DEVELOPED

- Based on immersion equilibrium sorption followed by desorption diffusion
- As adaptation of ASTM D471 for elastomers and ASTM D543 for thermoplastics
- Correlatable to the single droplet desorption geometry
- And over 30 polymeric materials have been tested and documented in the CDMD using 3 agents.

A NBCCS HARDNESS TEST METHOD HAS BEEN DEVELOPED FOR CHEMICAL EFFECTS ON MECHANICAL PROPERTIES

- Based on immersion exposure of standard tensile specimens
- As an adaptation of ASTM D543/D638 for thermoplastics or ASTM D471/D412 for elastomers
- Providing a measurement of chemical sorption
- And two materials have been tested to evaluate/validate the method using a variety of decontamination solutions at other independent labs.

Acknowledgements

The author would like to acknowledge the program support of P. Grasso, A. Steumpfle, D. Baylor, L. D'Elicio, M. Kaufman, and S. Lawhorne, Aberdeen Proving Ground.

The author is also grateful for the technical and manuscript preparation assistance from staff of the Information Analysis Center (IAC) and Battelle Edgewood Operations, including J. McNeely, S. Jones, J. Shetterly, V. Cummings, J. McClure, M. Weaver, C. Braungart, H. Cowan, and B. Claunch, and from co-workers V. McHugh and B. Ince.

The author appreciates database application assistance from co-op student contractors M. Cernik and A. Dudek

OFFGASING MODELING USING BOUNDARY LAYER PHENOMENA

Mr. John S. Moorehead

Research Scientist
Battelle Memorial Institute
Columbus, OH

Intentionally Left Blank

Battelle
... Putting Technology To Work

Off-gassing Hazard Modeling Close to Large Systems Using Boundary Layer Phenomena

Residual Chemical Hazard Model (RCHEM)

John S. Moorehead

User Requirements

Battelle
... Putting Technology To Work

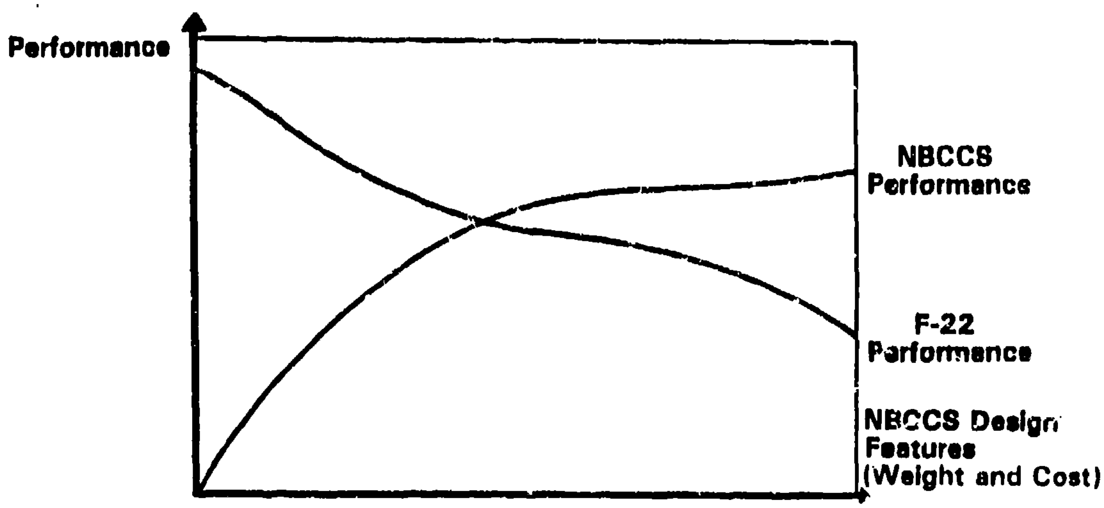
NBCCS

- Design Requirements of Future Weapons Systems Must Reduce Personnel Risks

Weapon System Requirements

- F-22 Advanced Tactical Fighter (ATF) Has a System Level Requirement to Demonstrate Decontaminability to Negligible Risk Levels
  - System Decontamination Process
    - Forced Hot Air (Interior)
    - Hot Soapy Water (Exterior)
  - Analysis Determined Most of the Hardware Was Accessible to Agent Vapor
  - Operational Scenario Includes Maintenance Personnel Working on and Close to the Aircraft
  - Cost and Weight Constraints Require Designing to a Realistic Threshold for CW Survivability

Performance Trade-offs



This Graph Illustrates the Trade-off Between NBCCS Performance (Weight and Cost) and Aircraft Performance as NBCCS Design Features are Added

Model Requirements

Battelle
... Putting Technology To Work

Computer Model to Predict Dose Generated Close to a Large Contaminated System

- Models
  - Exterior Off-gassing Hazard
  - Interior Off-gassing Hazard
- Accounts for
  - Multiple Materials and Off-gassing Rates at Discrete Locations
  - System Geometry
- Personnel Location
  - On or Under Aircraft
  - Within 1 Meter of Outer Mold Line
- Variable Wind Direction
- Upwind Agent Concentration
- Blister and Nerve Agents
- IBM and Macintosh PC Compatible

Comparison of NBCCS Top Model to Requirements

Battelle
... Putting Technology To Work

Requirement	NBCCS Top Model	Top Model With Modifications
Exterior Hazard	Yes	Yes
Interior Hazard	No	Yes
Multiple Materials	No	Yes
Multiple Off-gassing Rates	No	No
Discrete Locations	No	No
System Geometry	No	No
Personnel Locations	No	No
Variable Wind Direction	No	No
Upwind Agent Concentration	No	No
Blister and Nerve Agents	Yes	Yes
IBM and Macintosh Compatibility	No	Yes

Model Overview

Battelle
... Putting Technology To Work

Goal:

- To Provide System Level Analysis and Hazard Evaluation Using Material Level Approach

Approach:

- Analysis of Operational, System, and Environmental Conditions and Source Strength Testing to Determine Model Input values
- Flow Modeling Using Recursive Solutions to Navier-Stokes Boundary Layer Calculations and Physical Depiction of the Aircraft to Transport Agent Vapors to User Selected Locations of Interest and Generate Dose Profiles
- Code Development Using Excel and C Code to Provide a User Friendly PC Computer Package to Perform Calculations

Source Strength Testing

Battelle
... Putting Technology To Work

Low Concentration Exposure

Hot Air Decontamination

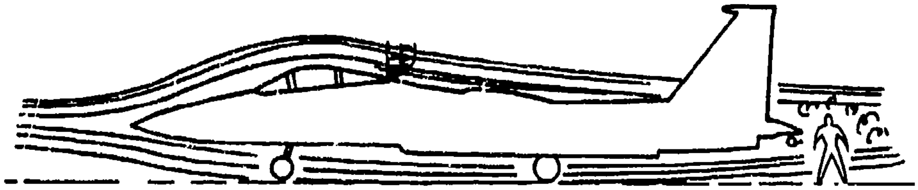
Residual Hazard Measurement

Flow Modeling

Battelle
... Putting Technology To Work

Flow Modeling Using Boundary Layer Flows Provides Analysis of the Mixing Volume for Off-gassing Agent. This Technique Accounts for:

- System Geometry
- Material and Personnel Locations
- Wind Direction
- Agent Concentration



Code Development

Battelle
... Putting Technology To Work

The Model was Encoded Into a User Friendly Computer Package for Speed and Ease of Operation

- Incorporates
  - Interior Hazard
  - Exterior Hazard
  - Materials Off-gassing Data
  - Variable Observer Locations
  - System Geometry
  - Flow Modeling (Recursive Solution to Navier-stokes Flow Equations)
  - Wind Path Search Algorithm

- Computer Platform
  - IBM Compatible Executable C code and EXCEL
  - Macintosh Executable C code and EXCEL

Comparison of RCHEM and Top Model to Requirements

Battelle
. . . Putting Technology To Work

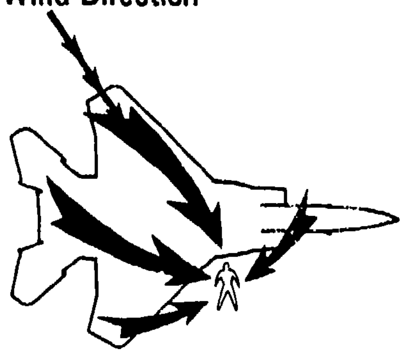
Requirement	NBCCS Top Model (Modified)	RCHEM Model
Exterior Hazard	Yes	Yes
Interior Hazard	Yes	Yes
Multiple Materials	Yes	Yes
Multiple Off-gassing Rates	No	Yes
Discrete Locations	No	Yes
System Geometry	No	Yes
Personnel Locations	No	Yes
Variable Wind Direction	No	Yes
Upwind Agent Concentration	No	Yes
Blister and Nerve Agents	Yes	Yes
IBM and Macintosh Compatibility	Yes	Yes

Comparison to NBCCS TOP Model - Results

Battelle
. . . Putting Technology To Work

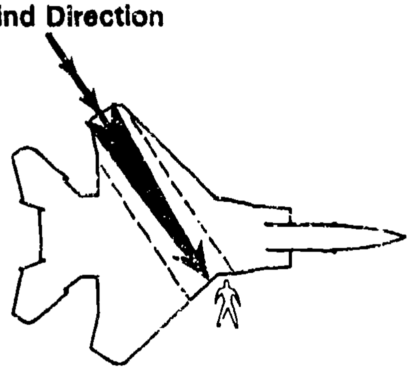
Using an F-15 Aircraft, a Hypothetical Average Mass Flux of 0.00001 mg/sec·cell and an Observer Located as Shown Below. The Two Models, Calculate the Following Doses

Wind Direction



NBCCS TOP Prediction
0.025 mg·min/m^3

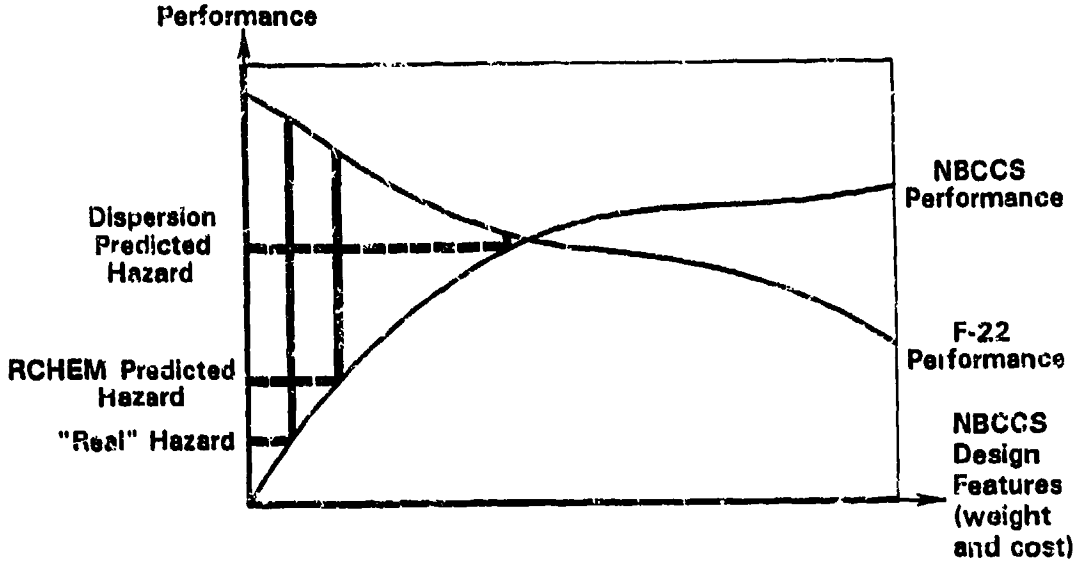
Wind Direction



RCHEM Model Prediction
0.0018 mg·min/m^3

Performance Trade-offs

Battelle
. . . Putting Technology To Work



F-22 Performance: Weight, Speed, Range, Stealth, Cost
NBCCS Performance: Ability to Meet Decontamination Criterion

RCHEM Capabilities

Battelle
. . . Putting Technology To Work

Current	Future Additions
Desorptive Off-gassing	Evaporation
Worst Case Predictions - By location - By system	"Actual case" predictions - By location "Median case" predictions - Stochastic environmental variability functions - Distribution function for observer location
Simplified system geometry	Refined system description - Integration with geometry models such as FASTGEN 4, BRL-CAD, etc. - Line depositions - Refined grid
Text input and output	Graphical representations

Comparison to Existing Models - Parameters Specific to the F-22

Battelle
... Putting Technology To Work

Additional Capabilities

Variable	NBCCS Top	RCHEM 1.0 Present	RCHEM Future
Geometry	No	Simplified Shapes	Refined Shapes
Wind - Direction	Direct downwind path	Search for worst case - based on geometry/material/location	User select
- Velocity	No	No	Yes
Temperature	No	Input parameters only	Yes
Line Depositions	No	No	Yes
Upstream Concentrations	No	Yes (step function)	Yes (integral)

Uses

Battelle
... Putting Technology To Work

Applications	Example Systems
System Design Tool	Any large system personnel must work on or around
System Evaluation Tool	- Tracked Vehicles - Wheeled Vehicles - Shelters - Aircraft
Experimental Design Tool	
Instrumentation Selection	
Decontamination Development - Techniques - Protocols	
Operational Restrictions	

Summary

Battelle
... Putting Technology To Work

- Provides Realistic Dose Predictions For Personnel Close to the Aircraft
- Flexible Process (Allows User Input for Operational and Environmental Parameters)
- User Friendly Computer Application
- Provides Permanent Database for the System
- Useful Design Optimization Tool

Intentionally Left Blank

ADVANCED TACTICAL FIGHTER (F-22) CHEMICAL HARDENING PROGRAM

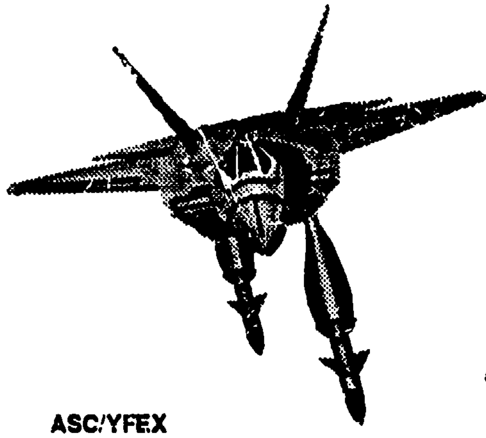
Lt. Jim Gehringer

F-22 Survivability Analyst
F-22 System Program Office
Wright-Patterson AFB, OH

Intentionally Left Blank

APPROVED FOR PUBLIC RELEASE

F-22 CHEMICAL SURVIVABILITY



Presented By: ASC/YFEX
Hugh Griffis/ Lt. Jim Gehringer
Vulnerability/ Live Fire Test Lead

Presented On: 15 June 1994

APPROVED FOR PUBLIC RELEASE

F-22 TEAM MEMBERS

- F-22 SPO (ASC/YF)
- LOCKHEED (LASC AND LFWC)
- BOEING
- PRATT/WHITNEY
- BATTELLE

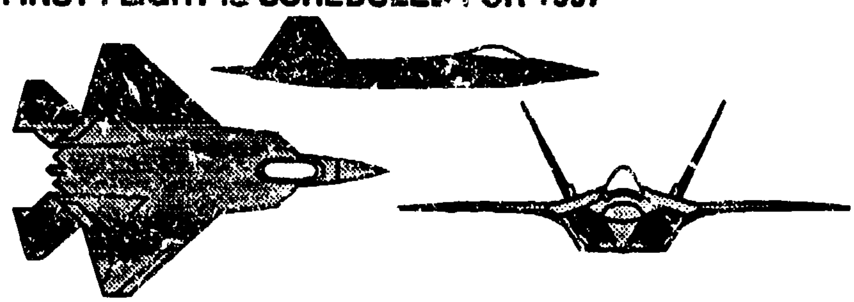
- HUMAN SYSTEM CENTER (HSC/YAC)
- DUGWAY PROVING GROUND (JCP)
- EGLIN AFB (46TH TEST WING)
- ACC/DRB

F-22 OVERVIEW

- F-22 PROGRAM OVERVIEW
- REQUIREMENTS
- THREAT ALLOCATION
- F-22 DECONTAMINATION CONCEPT
- DESIGN CONCEPTS
  - EXTERNAL SURFACES
  - INTERNAL SURFACES
  - PILOT
- F-111 CHEMICAL TEST
- RELATIONSHIP OF EFFORTS
- PROGRESS AND FUTURE PLANS
- SUMMARY

F-22 PROGRAM OVERVIEW

- THE F-22 PROGRAM ENGINEERING AND MANUFACTURING (EMD) PHASE BEGAN IN AUGUST 1991
- FIRST FLIGHT IS SCHEDULED FOR 1997



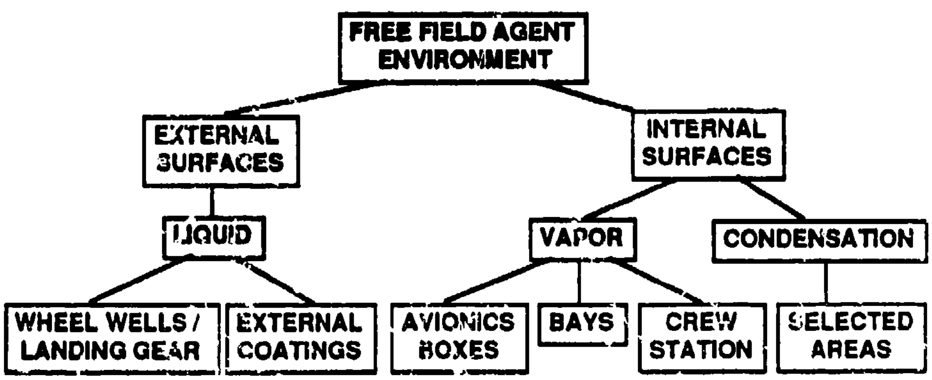
- THE F-22 IS THE REPLACEMENT FOR THE F-15 AIR SUPERIORITY FIGHTER

F-22 REQUIREMENTS

- OPERATIONAL NEEDS
  - OPERATE IN A CONTAMINATED ENVIRONMENT WITH NO LOSS OF COMBAT CAPABILITY
  - PILOT AND MAINTENANCE CREWS PROTECTED FROM THREAT
  - ABILITY TO DECONTAMINATE THE AIRCRAFT
- PERFORMANCE REQUIREMENTS
  - NO LOSS OF COMBAT CAPABILITY FOR x DAYS
  - EQUIPMENT DESIGNED TO ALLOW MAINTENANCE ACTIVITIES
  - 95th PERCENTILE PILOT NOT DAMAGED
  - DECONTAMINATION IN y HOURS
- THREAT
  - 95th PERCENTILE FREE FIELD ENVIRONMENT
  - BOTH LIQUID AND VAPOR CHALLENGE

F-22 THREAT ALLOCATION

- INTERNAL SURFACES ARE EXPOSED TO VAPOR AGENT
  - IF AIR CAN GET TO THE SURFACE, IT IS EXPOSED TO VAPOR
  - DRAIN HOLES ALLOW AGENT TO CONTAMINATE BOXES
- EXTERNAL SURFACES ARE EXPOSED TO LIQUID AGENT

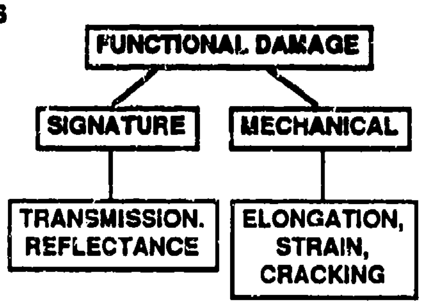


F-22 DECONTAMINATION CONCEPTS

- SENSITIVE MATERIALS AND AVIONICS CAN'T BE CHEMICALLY DECONTAMINATED (BLEACH, DS2, ETC.)
- ONLY PHYSICAL DECONTAMINATION IS PLANNED
  - EXTERNAL SURFACES: HOT SOAPY WATER OR FLIGHT
  - INTERNAL BAYS: FORCED HOT AIR
- MATERIALS MUST NOT BE DEGRADED BY EITHER AGENT EXPOSURE OR SUBSEQUENT DECONTAMINATION

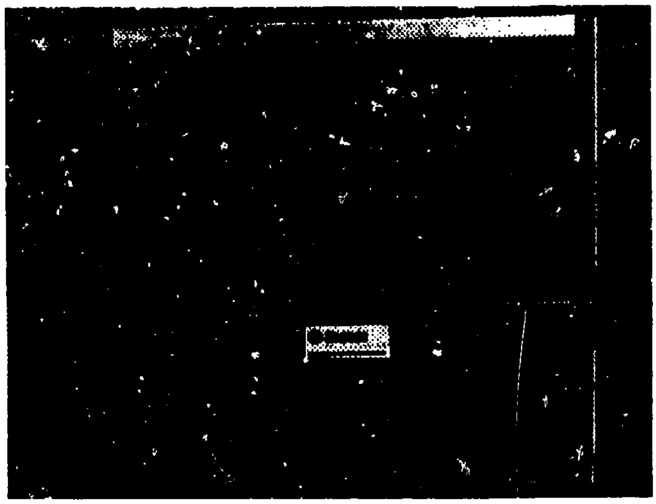
F-22 EXTERNAL SURFACES DESIGN CONCEPTS

- CHEMICAL RESISTANT COATING COVER MATERIALS
  - CONDUCTED MATERIALS TESTS FOR MECHANICAL AND SIGNATURE PROPERTIES

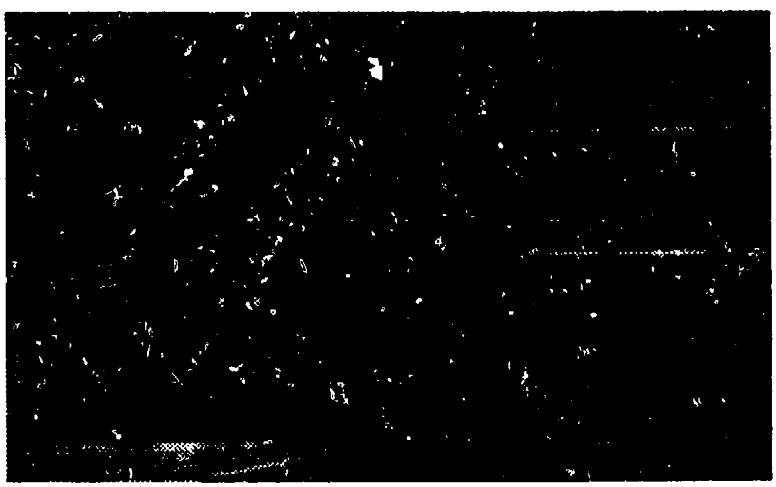


- DECONTAMINATE SURFACES WITH HOT SOAPY WATER AND FLYING THE AIRCRAFT
  - MUST DECONTAMINATE FOR BOTH CONTACT AND OFF-GASSING HAZARD

F-22 REFLECTANCE TEST



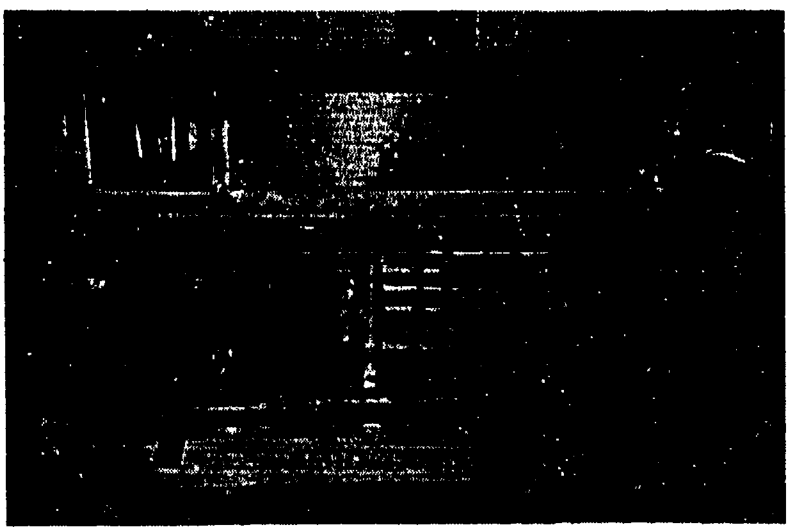
F-22 TRANSMISSION TEST



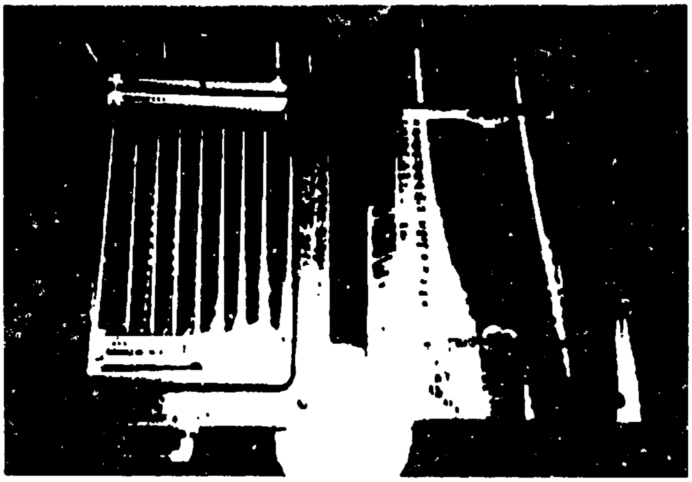
F-22 INTERNAL SURFACES DESIGN CONCEPTS

- **CHEMICAL RESISTANT COATING COVERED MATERIALS**
  - EXCEPTIONS ARE TESTED TO SUPPORT A HAZARD ASSESSMENT
  - MATERIALS ARE TESTED IN A SPECIAL VAPOR TEST CHAMBER
- **REQUIREMENTS FOR EDGES, CORNERS, AND HANDLES**
  - MAINTENANCE ACTIVITIES CAN BE PERFORMED WHILE MAINTAINER IS WEARING CHEMICAL GEAR
- **DECONTAMINATE SURFACES AND EQUIPMENT**
  - HOT FORCED AIR INJECTED BY ENGINE START/ AIR CONDITIONING CARTS
  - REPLACE ALL FLUIDS (HYDRAULIC FLUID, FUEL, ETC)
  - REMOVE AND REPLACE NON-DECONTAMINABLE EQUIPMENT
  - MUST DECONTAMINATE FOR BOTH CONTACT AND OFF-GASSING HAZARD

F-22 VAPOR TEST SET-UP



F-22 COUPON TEST CHAMBER

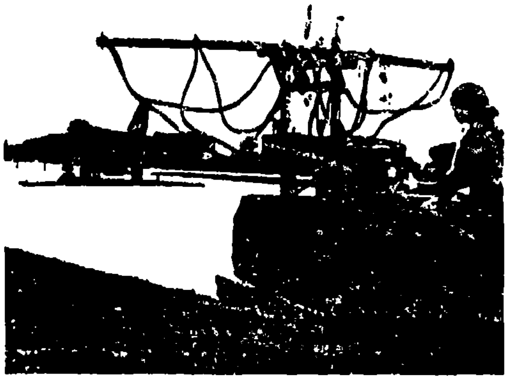


F-22 PILOT INTERFACE DESIGN CONCEPTS

- **FILTER AIR GOING TO PILOT**
  - FILTER IS INTEGRATED INTO THE AIRCRAFT ENVIRONMENTAL CONTROL SYSTEM
  - FILTER IS ACCESSIBLE TO MAINTAINER IN CHEMICAL GEAR
- **PILOT CHEMICAL PROTECTION INTEGRATED INTO THE COLD WATER IMMERSION ENSEMBLE**

F-22 F-111 HOT AIR DECONTAMINATION

- STUDIED 3 METHODS OF DECONTAMINATION:
  - AVOIDANCE
  - IN-FLIGHT
  - FORCED HOT AIR
- VAPOR CLOUD GENERATOR

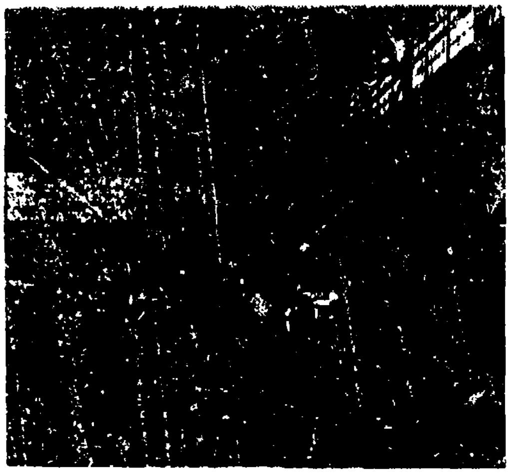


F-22 F-111 HOT AIR DECONTAMINATION

- ENGINE INJECTION CONTAMINATION

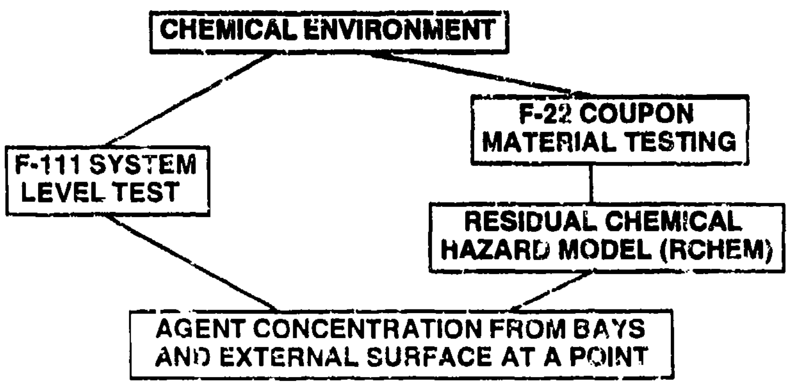
F-22 F-111 HOT AIR DECONTAMINATION

- AGENT CONCENTRATION SAMPLING IN AVIONICS BAYS



F-22 RELATIONSHIP OF EFFORTS

- BY STUDYING THE F-22 DESIGN BOTTOM UP AND THE TESTING THE F-111 AIRCRAFT TOP DOWN, WE ARE OBTAINING THE MAXIMUM AMOUNT OF DATA

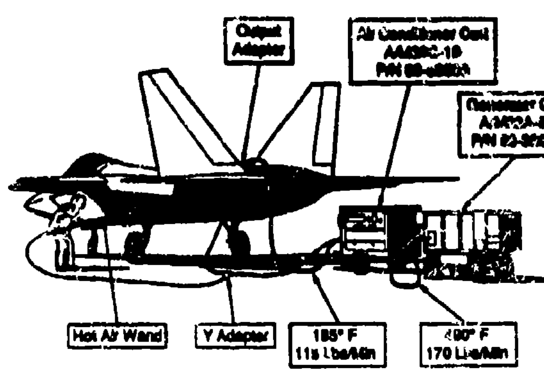


F-22 PROGRESS AND FUTURE PLANS

- SYSTEM LEVEL DECONTAMINATION TEST USING AN F-111 AIRCRAFT HAS DEMONSTRATED THE F-22 FORCED HOT AIR DECONTAMINATION CONCEPT
- OUR GOAL IS TO CORRELATE THE "RCHEM" RESULTS WITH THE F-111 SYSTEM TEST
  - F-111 MATERIAL COUPON TESTS USING THE SIMULANT AND TEST CONDITIONS ARE NEEDED FOR RCHEM ANALYSIS
- THE F-22 WILL CONDUCT A SIMILAR SYSTEM LEVEL TEST IN THE ENGINEERING MANUFACTURING DEVELOPMENT (EMD) PROGRAM

F-22 F-22 SYSTEM LEVEL DECONTAMINATION

- FORCED HOT AIR IS INJECTED INTO THE AIRCRAFT



F-22 SUMMARY

- THE TEAM HAS MADE GREAT PROGRESS TOWARDS UNDERSTANDING AIRCRAFT CHEMICAL HARDENING
  - OPERATIONAL CONCEPT/RESTRICTIONS IDENTIFIED
  - THREAT ALLOCATED TO REGIONS OF AIRCRAFT
  - DESIGN APPROACH ESTABLISHED
  - LIST OF MATERIALS EXPOSED TO CHEMICAL AGENTS HAS BEEN DEVELOPED
  - MATERIAL COUPON TEST PROCEDURES DEVELOPED FOR VAPOR THREAT
  - F-22 MATERIALS DATA BEING OBTAINED FOR:
    - VAPOR THREAT
    - LIQUID THREAT
    - FUNCTIONAL DAMAGE
  - FORCED HOT AIR DECONTAMINATION METHOD DEMONSTRATED
  - ANALYSIS TOOL DEVELOPED

Intentionally Left Blank

CARGO AIRCRAFT (C-130) CONTAMINATION CONTROL PROGRAM

Dr. Ngai Wong

Program Manager
U.S. Air Force Armstrong Laboratory
Crew System CB Defense Division
Project Reliance Team
U.S. Army Chemical and Biological Defense Command
Aberdeen Proving Ground, MD

Intentionally Left Blank

CARGO AIRCRAFT CONTAMINATION CONTROL

Ngai M. Wong, PhD
USAF Armstrong Laboratory
Crew System CB Defense Division
Project Reliance Team
CBDCOM
Aberdeen Proving Ground, Maryland

OUTLINE

Requirements

Program

Phase I - Ventilation Trials

- Trial Conditions
- Flight Configurations
- Test Results

Phase II - In-flight Contamination Trials

- Trial Conditions
- Flight Configurations
- Test Results

Summary

REQUIREMENTS

- AF SON 004-85
- AMC ORDs
  - Aircraft Interior Decontamination
  - Aircraft Interior Detection

PROGRAM

Phase I - Ventilation Trials

Phase II - In-Flight Contamination Control

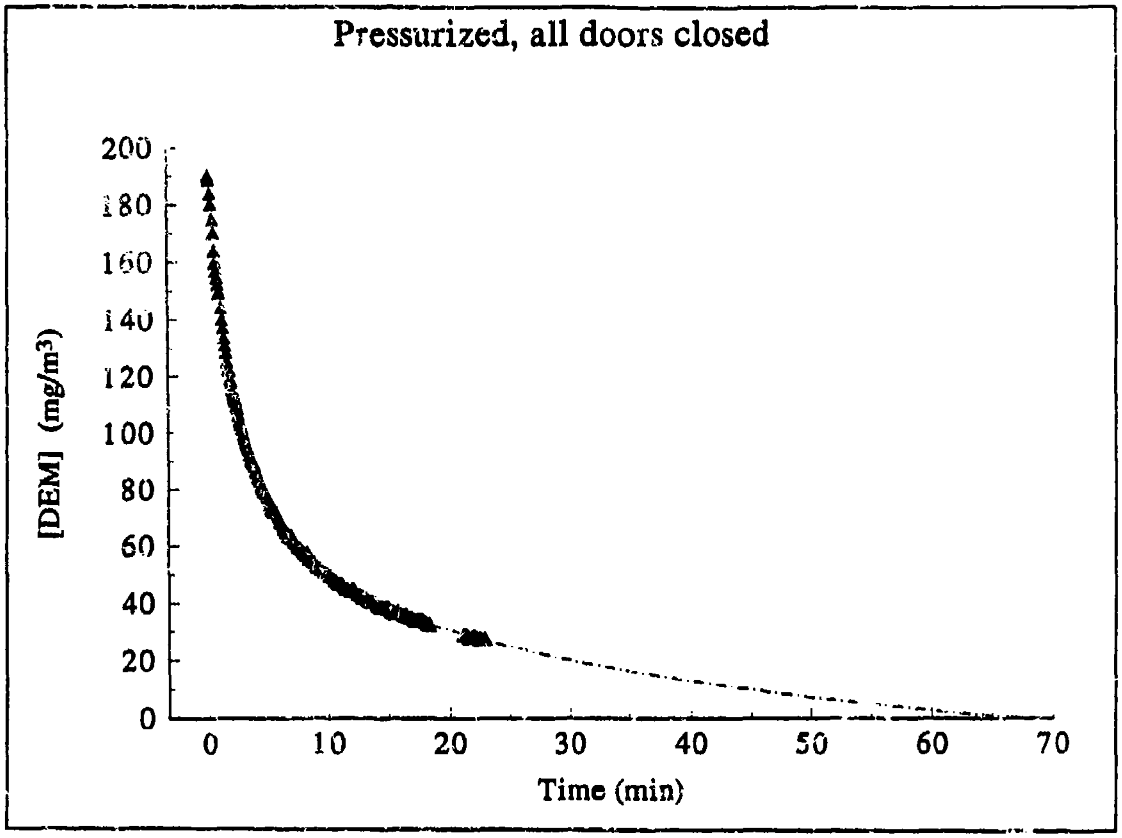
Phase III - Upload Ground Operations

Diethyl Malonate (DEM)	1922 mg/m^3 at 25 °C
GD	3922 mg/m^3 at 25 °C

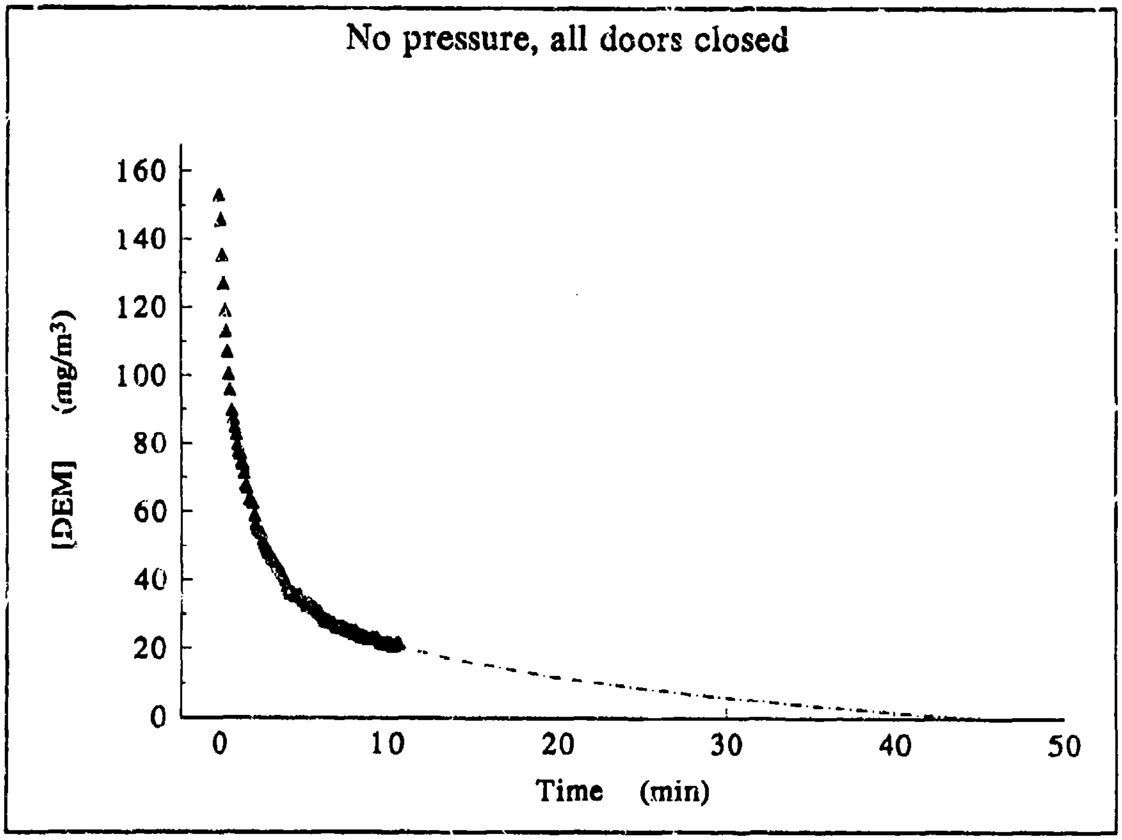
Typical Trial Conditions of Using DEM

- VAPOR CHALLENGE ONLY
- Concentration of 150 - 200 mg/m^3 inside cargo bay
- Collect concentration data down to 10 - 20 mg/m^3
- Extrapolate data to myosis levels, 0.05 mg/m^3

Configuration	Flight Conditions
1. Pressurized, all doors closed	10,000 Ft and 20,000 Ft altitudes, ambient temperature, and cruise velocity
2. No pressure, all doors closed	10,000 Ft altitude, ambient temperature, and cruise velocity
3. Pressurized, auxiliary vent, all doors closed	10,000 Ft and 20,000 Ft altitudes, ambient temperature, and cruise velocity
4. No pressure, paratroop door open	10,000 Ft altitude, ambient and hot temperatures, and 150 KIAS
5. No pressure, ramp & cargo door open	10,000 Ft altitude, ambient and hot temperatures, and 150 KIAS
6. No pressure, cargo door open	10,000 Ft altitude, ambient and hot temperature, and 185 KIAS

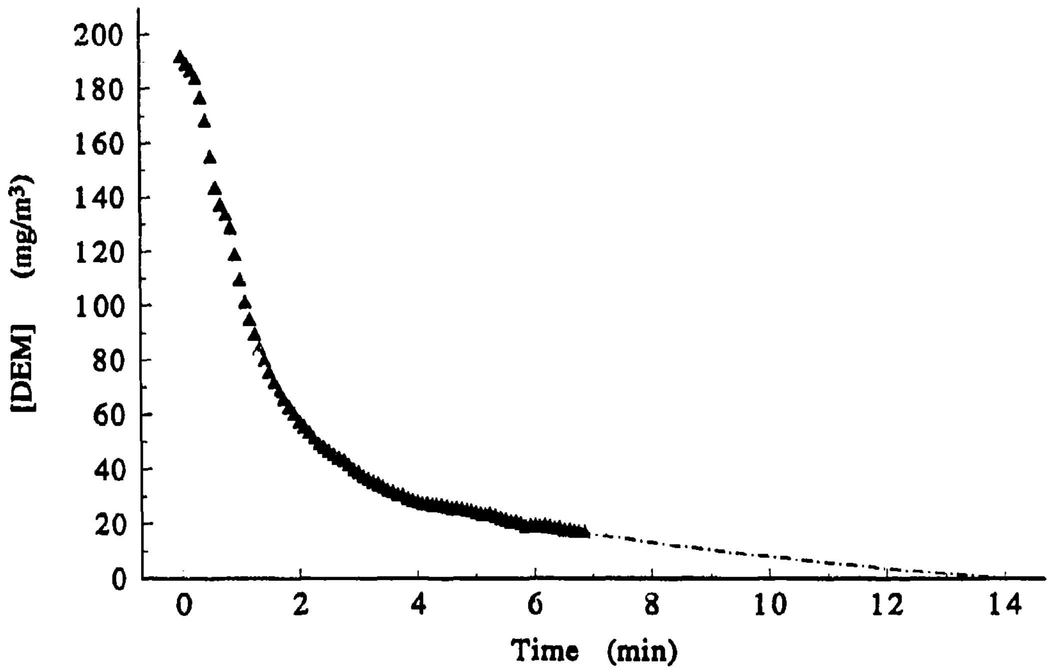


Pressurized, all doors closed
[DEM] (mg/m³)
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Time (min)

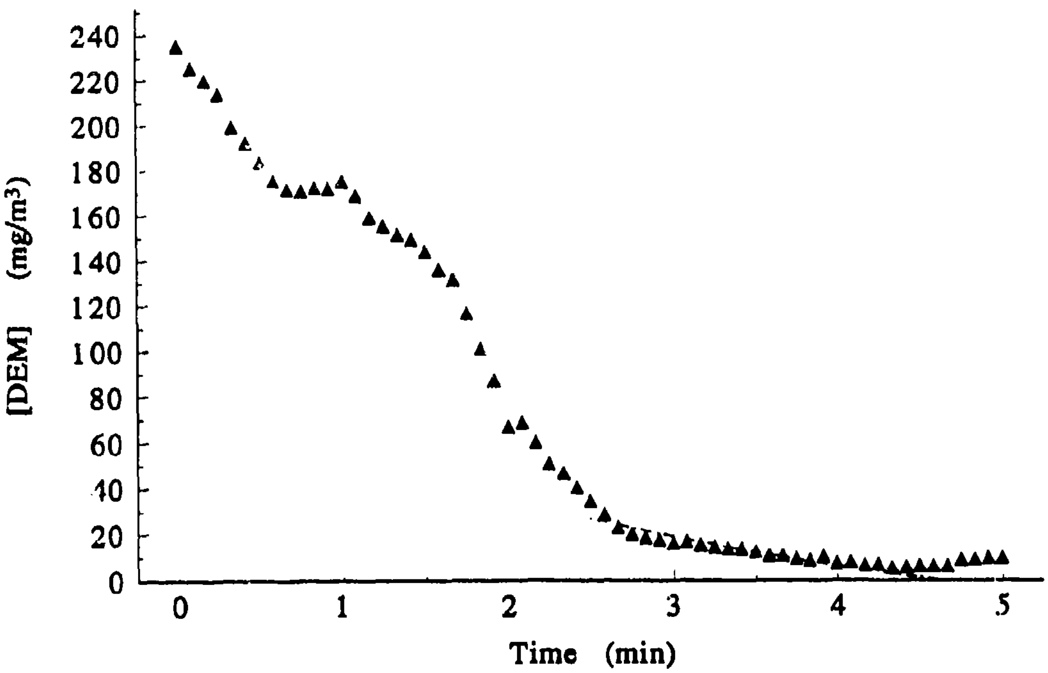


No pressure, all doors closed
[DEM] (mg/m³)
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
Time (min)

Pressurized, auxiliary vent, all doors closed



No pressure, paratroop doors open



Test Results

- Pressurized to 8,000 Ft at altitudes of 10,000 Ft and 20,000 Ft
  - •• no significant difference between altitudes
  - •• 65 - 70 minutes to clear
- No pressurization at 10,000 Ft altitude
  - •• 45 minutes to clear
- Pressurized, auxiliary vent
  - •• 14 minutes to clear at 10,000 Ft
  - •• 5 minutes to clear at 20,000 Ft

Test Results

- Paratroop doors
  - •• 5 minutes to clear (ambient and hot trials)
- Ramp & cargo door
  - •• 5 minutes to clear (ambient and hot trials)
- Cargo door
  - •• 10 minutes to clear, ambient trial
  - •• 5 minutes to clear, hot trial

Additional Observations

- Flight deck relatively free of contamination
  - High level of contamination in cargo area below 5 mg/m^3 in flight deck
- Air leakage from front of aircraft to rear
- Liquid DEM observed on floor

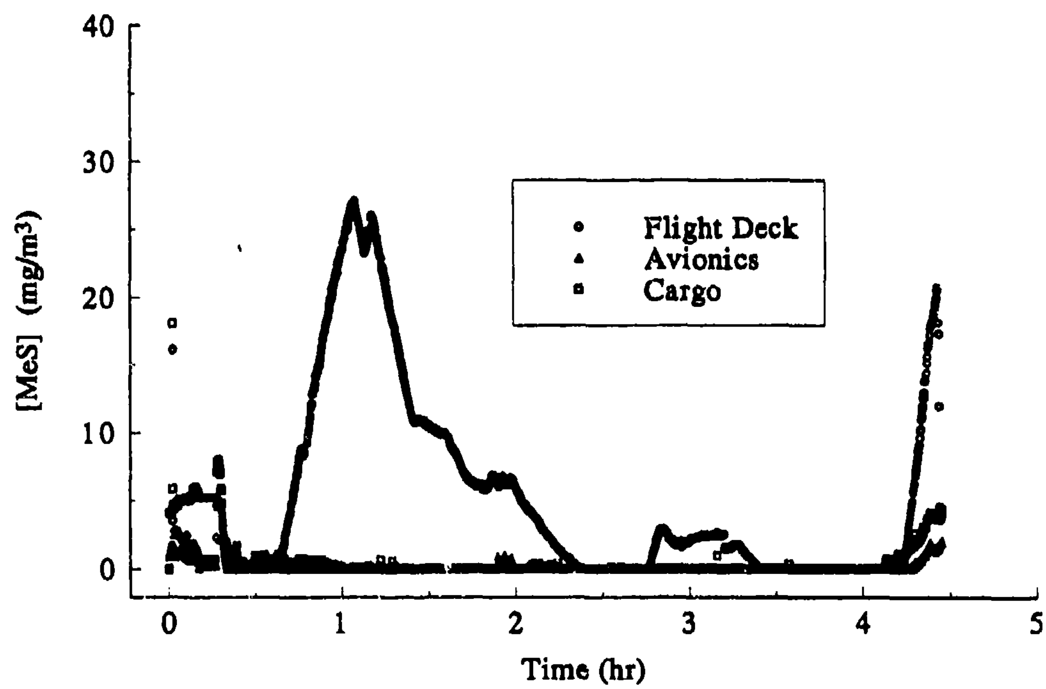
Methyl Salicylate (MeS)	1060 mg/m^3 at 25 °C
HD	911 mg/m^3 at 25 °C

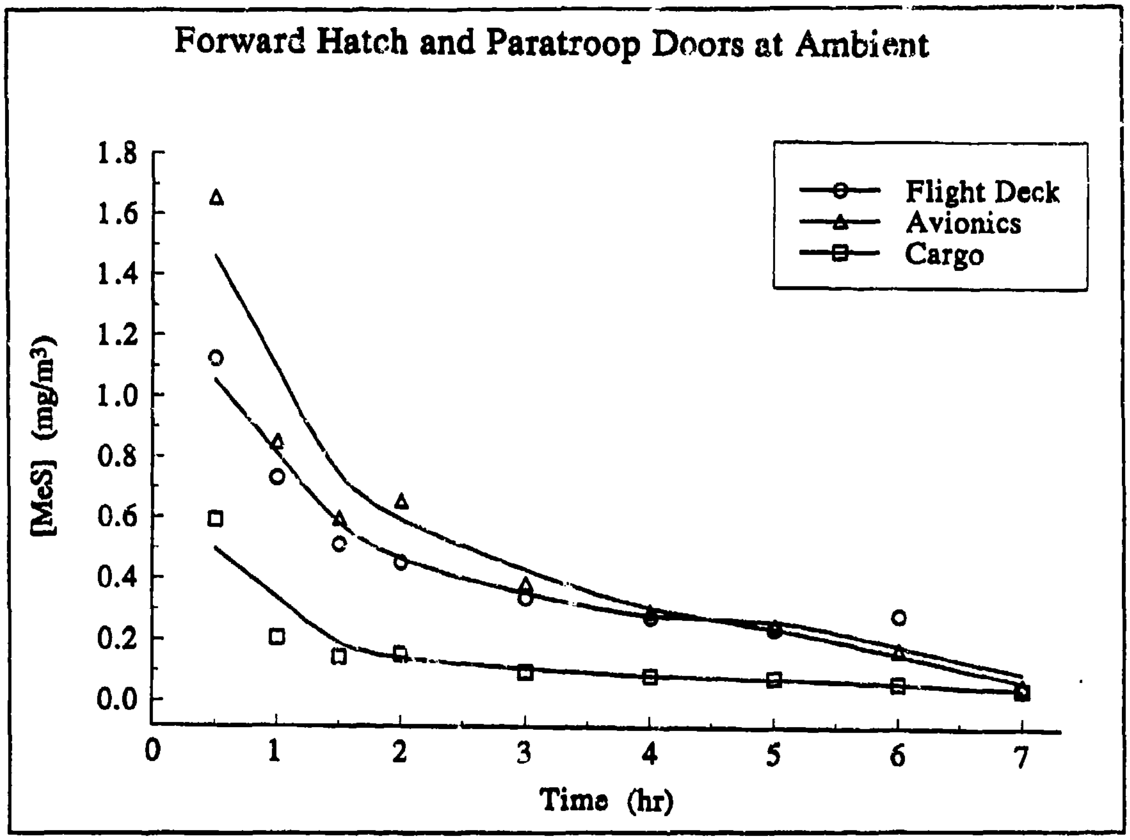
Typical Trial Conditions of Using MeS

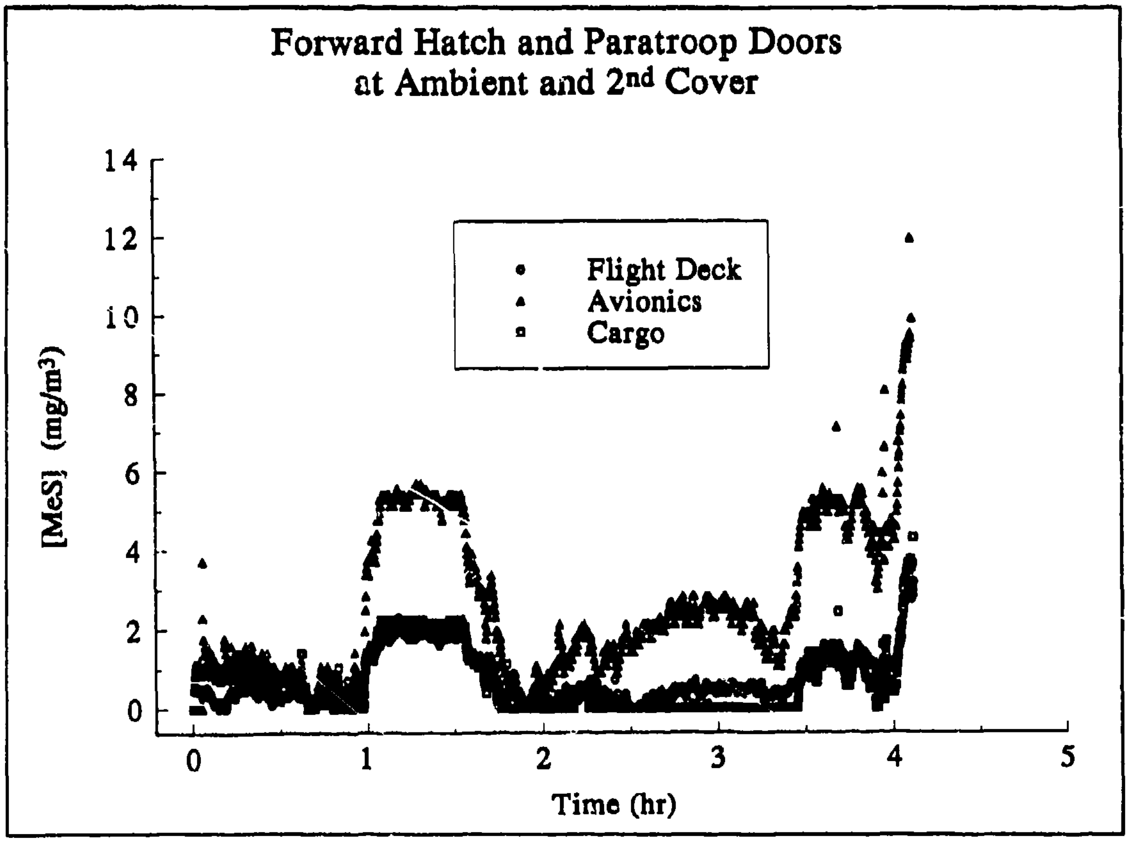
- Liquid Contaminated Cargo and Off-gassing Challenge
- Liquid concentrations of 5 g/m^2 on the cargo
- Collect liquid and off-gassing levels
- Use MIRAN, bubblers, swabs, and swatches for data collection

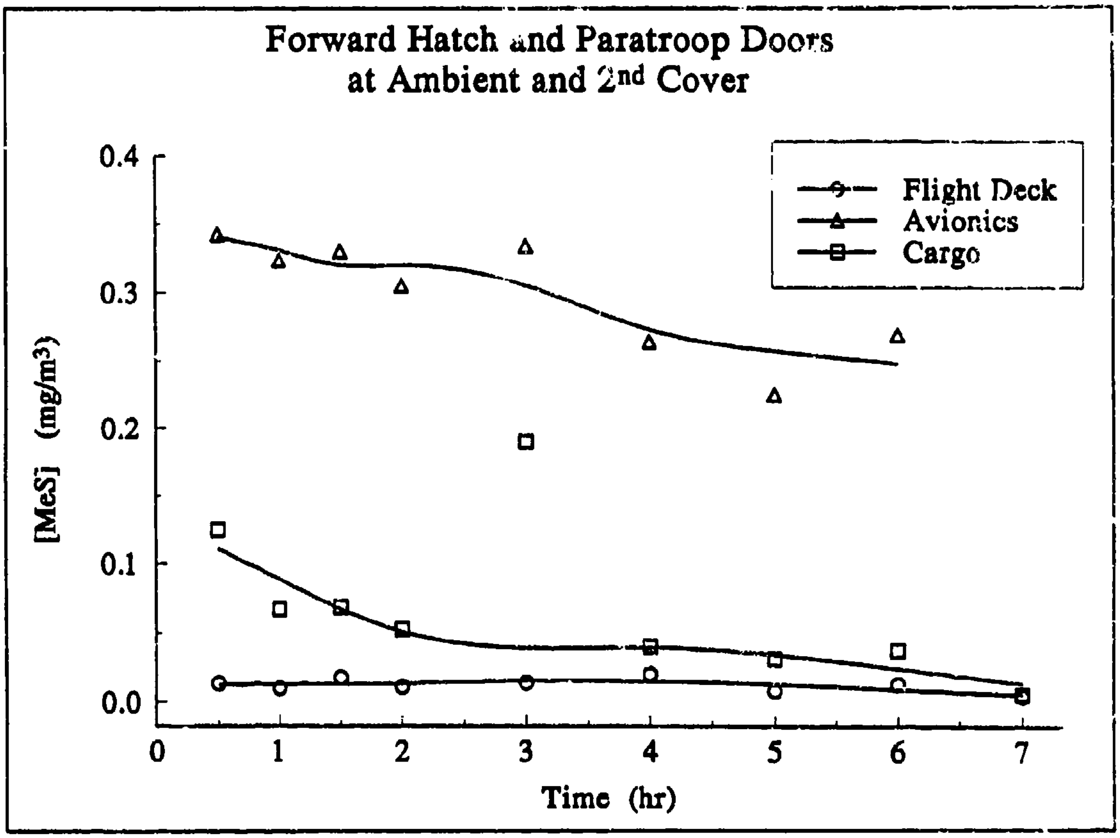
	Configuration	Flight Conditions
1.	Forward hatch and paratroop doors	10,000 Ft altitude, ambient temperature, and 150 KIAS
2.	Auxiliary vent	10,000 Ft altitude, ambient temperature, and cruise velocity
3.	Auxiliary vent	10,000 Ft altitude, full on-board heaters, and cruise velocity

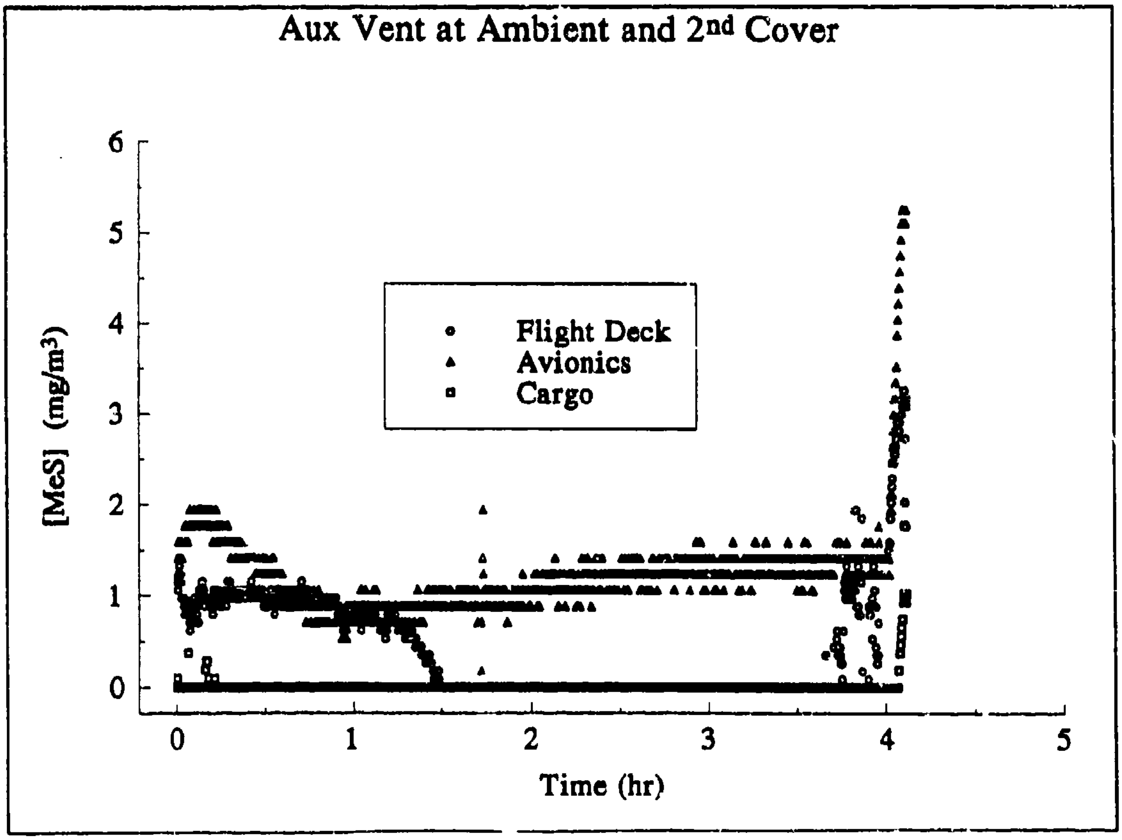
Forward Hatch and Paratroop Doors at Ambient

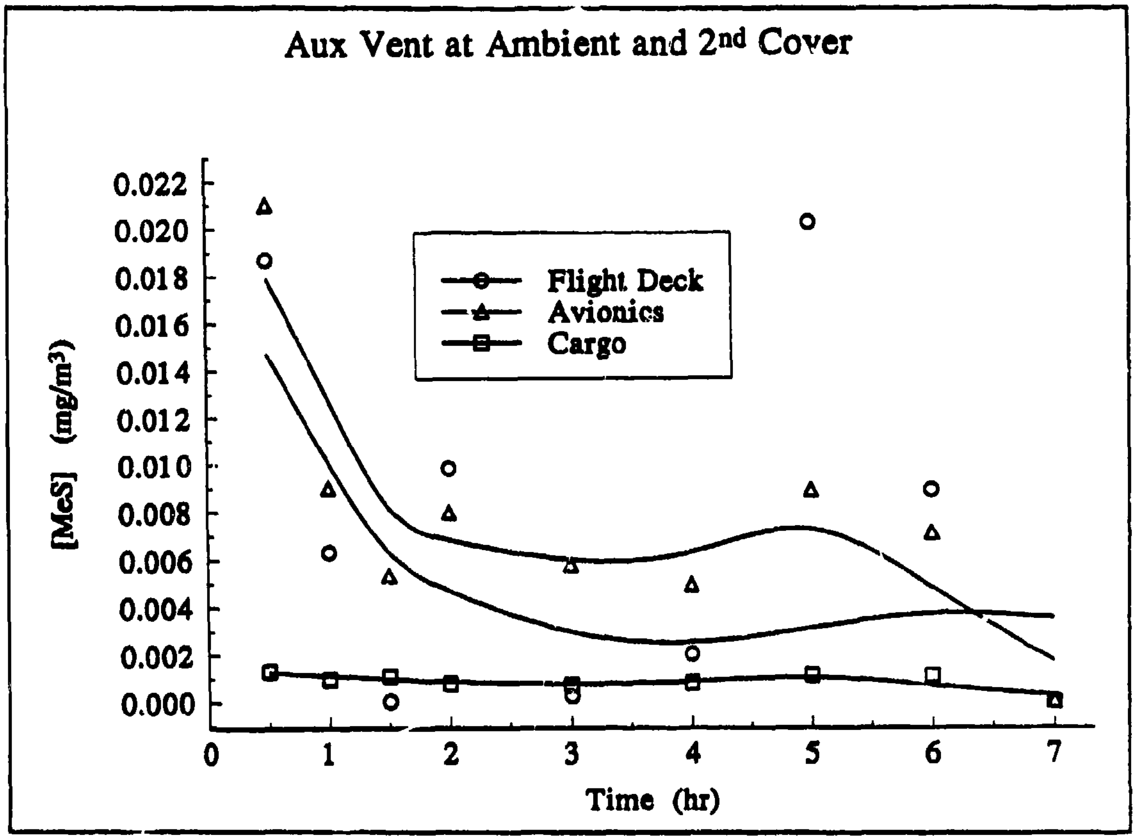


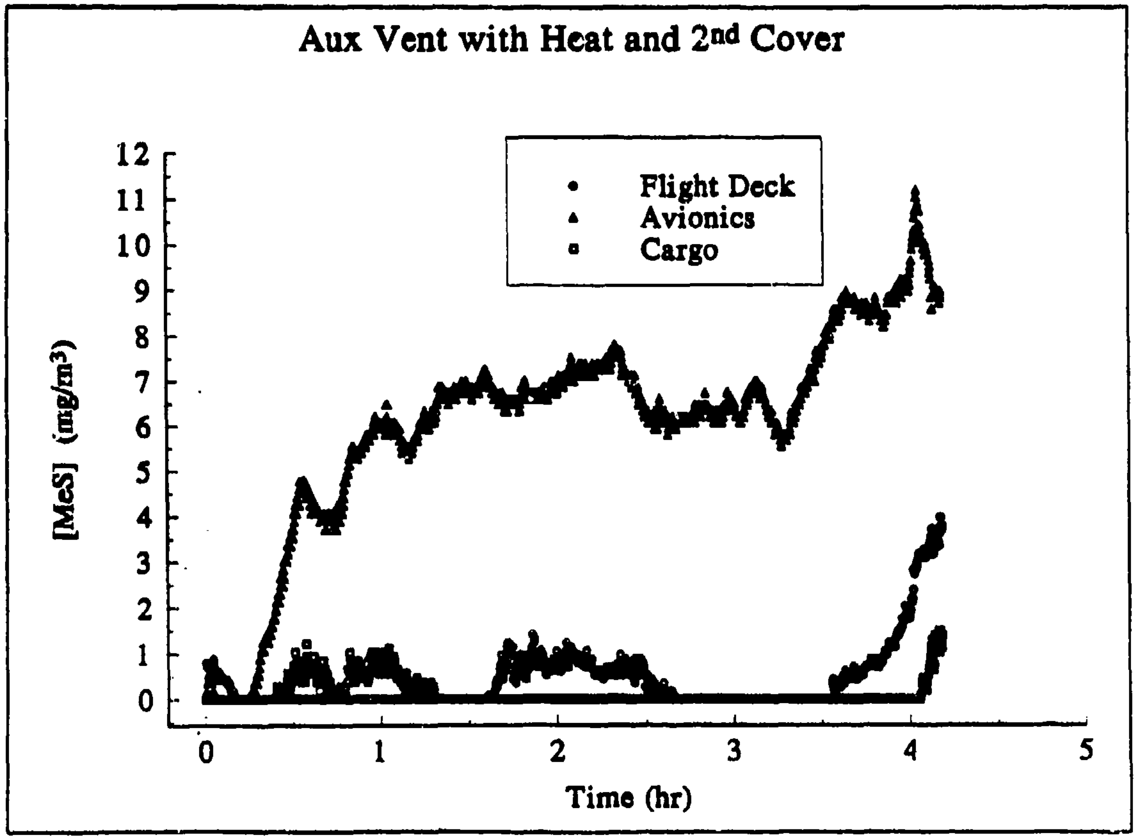

Forward Hatch and Paratroop Doors at Ambient
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
[MeS] (mg/m3)
0
1
2
3
4
5
6
7
Time (hr)
Flight Deck
Avionics
Cargo

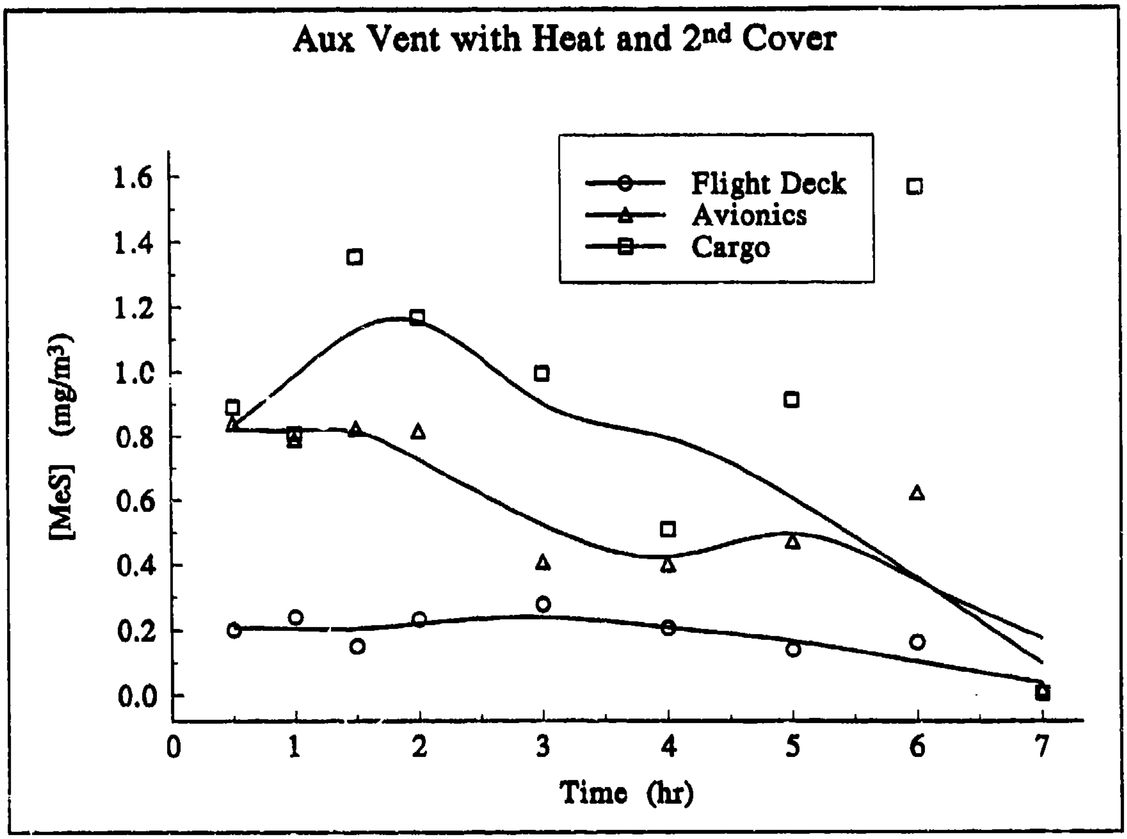

Forward Hatch and Paratroop Doors
at Ambient and 2nd Cover
14
12
10
8
6
4
2
0
[MeS] (mg/m3)
0
1
2
3
4
5
Time (hr)
Flight Deck
Avionics
Cargo

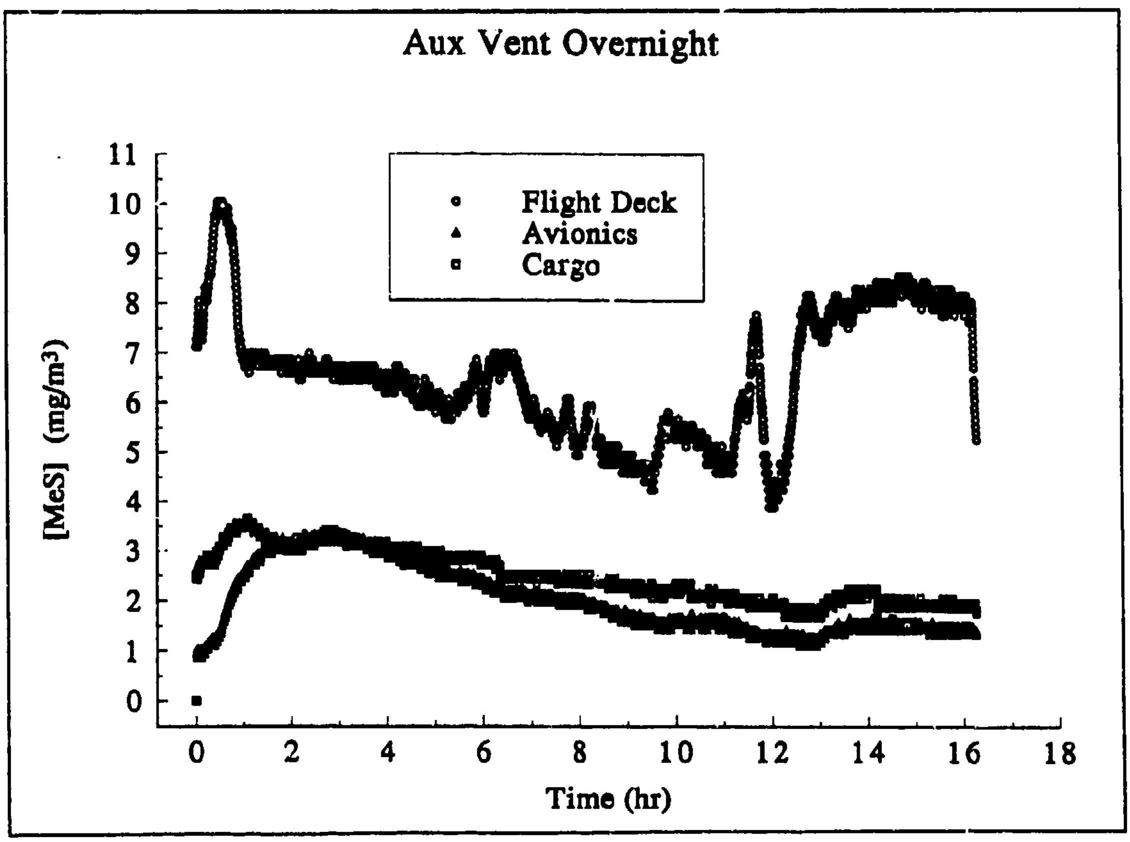

Forward Hatch and Paratroop Doors
at Ambient and 2nd Cover
Flight Deck
Avionics
Cargo
[MeSi] (mg/m3)
0.4
0.3
0.2
0.1
0.0
0
1
2
3
4
5
6
7
Time (hr)


Aux Vent at Ambient and 2nd Cover
Flight Deck
Avionics
Cargo
[MeSi] (mg/m3)
6
5
4
3
2
1
0
0
1
2
3
4
5
Time (hr)


Aux Vent at Ambient and 2nd Cover
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
[MeS] (mg/m3)
Flight Deck
Avionics
Cargo
0
1
2
3
4
5
6
7
Time (hr)


Aux Vent with Heat and 2nd Cover
12
11
10
9
8
7
6
5
4
3
2
1
0
[MeS] (mg/m3)
Flight Deck
Avionics
Cargo
0
1
2
3
4
5
Time (hr)


Aux Vent with Heat and 2nd Cover
Flight Deck
Avionics
Cargo
[MeS] (mg/m3)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
Time (hr)


Aux Vent Overnight
Flight Deck
Avionics
Cargo
[MeS] (mg/m3)
11
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
Time (hr)

Test Results

- MIRAN
  - shows higher concentrations of contaminants
  - shows serious problem in adsorption of contaminants
- Bubblers
  - shows lower levels of contamination but still unsafe
- Liquid sampling of cargo
  - 2 - 8 g/m^2 contamination at start
  - 0.8 - 5 g/m^2 contamination after one (1) hour weathering
  - 0.1 - 2 g/m^2 contamination after flight operation

SUMMARY

- Complex processes observed in ventilation of an empty aircraft
- Temp and altitude have only small effects on vapor challenge for an empty aircraft
- Vapor challenge can be cleared in 5 minutes for an empty aircraft
- Liquid contamination makes a bigger problem of vapor challenge
- Off-gassing a serious problem, high levels of contamination
- Airflow patterns keeps contamination near front of aircraft
- Contamination remains with aircraft after contaminated cargo is removed

Intentionally Left Blank

MEETING AGENDA

Intentionally Left Blank

MEETING AGENDA

Wednesday, June 15, 1994

7:00 a.m.- 8:15 a.m.	**REGISTRATION** Edgewood Area Conference Center, Seminar Building, Austin and Hoadley Roads, Aberdeen Proving Ground (Edgewood Area), MD
8:15 a.m.	**ADMINISTRATIVE REMARKS** *Mr. Louis S. D'Elicio,* Chemical-Biological and Nuclear Effects Division, U.S. Army Research Laboratory, Aberdeen Proving Ground (Edgewood Area), MD
8:20 a.m.	**INTRODUCTION** *Brigadier General Peter Hidalgo, USA (Ret),* Chairman, Chemical Division, American Defense Preparedness Association, Arlington, VA
8:25 a.m.	**MODERATOR'S REMARKS** *Mr. William J. Hughes,* Acting Chief, Chemical-Biological and Nuclear Effects Division, U.S. Army Research Laboratory, Aberdeen Proving Ground (Edgewood Area), MD
8:30 a.m.	**WELCOME ADDRESS** *Brigadier General George E. Friel, USA,* Commander, U.S. Army Chemical and Biological Defense Command, Aberdeen Proving Ground (Edgewood Area), MD
8:40 a.m.	**KEYNOTE ADDRESS** *Dr. John W. Lyons,* Director, U.S. Army Research Laboratory, Adelphi, MD
9:05 a.m.	**UPDATE ON NBCCS REGULATORY DOCUMENTS** *Dr. William S. Magee,* Advocate for NBC Survivability, Office of the Director for Chemical and Biological (CB) RDA, U.S. Army Chemical and Biological Defense Command, Aberdeen Proving Ground (Edgewood Area), MD
9:20 a.m.	**OVERVIEW OF MULTIPURPOSE INTEGRATED CHEMICAL AGENT ALARM (MICAD) PROGRAM** *Mr. Frank Belcastro,* MICAD Team Leader, U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground (Edgewood Area), MD
9:30 a.m.	**MICAD NBCCS PROGRAM PLAN & TEST AND EVALUATION** *Mr. Thomas M. McMahon,* Head, Chemical Surety, Calspan Corporation, Buffalo, NY

10:00 a.m. **BREAK**

10:20 a.m. **OVERVIEW OF THE ARMORED GUN SYSTEM (AGS) PROGRAM**
Mr. Albert P. Puzzuoli, Deputy Project Manager, Office of the Project Manager for AGS, Warren, MI

10:30 a.m **AGS PROGRAM NBCCS RISK ASSESSMENT METHODOLOGY**
Mr. Francisco Magno, AGS NBCCS Project Engineer, United Defense L.P., San Jose, CA

10:55 a.m. **NBCCS IN THE TACTICAL QUIET GENERATOR (TQG) PROGRAM**
Ms. Kelly Alexander, Project Engineer, Office of the DoD Project Manager for Mobile Electric Power, Springfield, VA

11:35 a.m. **NBCCS IN THE 120 MM MORTAR PROGRAM**
Mr. Edward Lewis, Project Engineer, Office of the Product Manager for Mortar Systems, Picatinny Arsenal, NJ

12:05 a.m. **NBCCS IN THE MINI EYESAFE LASER INFRARED OBSERVATION SYSTEM (MELIOS) PROGRAM**
Mr. Richard Renairi, Project Engineer, Office of the Project Manager for Night Vision and Electro Optics, Fort Belvoir, VA

12:25 p.m. **LUNCH FOR ALL ATTENDEES**
Edgewood Area Community Club, Aberdeen Proving Ground (Edgewood Area), MD

1:45 p.m. **VAPOR AND LIQUID TRANSPORT AND DIFFUSION MODELING (VLSTRACK)**
Mr. Timothy J. Bauer, Chemical Engineer, Chemical and Biological Systems Analysis Branch, Naval Surface Warfare Center, Dahlgren, VA

2:10 p.m. **CHEMICAL-BIOLOGICAL EFFECTS MODELING IN ARL**
Mr. William J. Hughes, Acting Chief, Chemical-Biological and Nuclear Effects Division, U.S. Army Research Laboratory, Aberdeen Proving Ground (Edgewood Area), MD

2:35 p.m. **OVERVIEW OF XM56 LARGE AREA SMOKE GENERATOR PROGRAM**
Mr. Ray Malecki, XM56 System Manager, Office of the Product Manager for Smoke/Obscurants, Aberdeen Proving Ground (Edgewood Area), MD

2:45 p.m. **XM56 NBCCS PROGRAM & APPLICATION OF TEST RESULTS**
Ms. Kathleen M. Considine, Project Engineer, Chamberlain MRC Corporation, Hunt Valley, MD

3:15 p.m. **BREAK**

3:35 p.m. **CHEMICAL RESISTANCE TEST PROGRAM FOR SELECTION/DESELECTION OF MATERIALS**
Mr. Wendel J. Shuely, Research Chemist, U.S. Army Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground (Edgewood Area), MD

4:05 p.m. **OFFGASING MODELING USING BOUNDARY LAYER PHENOMENA**
Mr. John S. Moorehead, Research Scientist, Battelle Memorial Institute, Columbus, OH

4:20 p.m. **ADVANCED TACTICAL FIGHTER (F-22) CHEMICAL HARDENING PROGRAM**
Lt. Jim Gehringer, F-22 Survivability Analyst, F-22 System Program Office, Wright-Patterson AFB, OH

4:45 p.m. **CARGO AIRCRAFT (C-130) CONTAMINATION CONTROL PROGRAM**
Dr. Ngai Wong, Program Manager, Project Reliance U.S. Air Force Liaison Office, U.S. Army Chemical and Biological Defense Command, Aberdeen Proving Ground (Edgewood Area), MD

5:15 p.m. **SYMPOSIUM WRAP-UP AND CLOSING REMARKS**
Mr. William J. Hughes, Acting Chief, Chemical-Biological and Nuclear Effects Division, U.S. Army Research Laboratory, Aberdeen Proving Ground (Edgewood Area), MD

5:20 p.m. **ADJOURN**

Intentionally Left Blank

LIST OF ATTENDEES

Intentionally Left Blank

LIST OF ATTENDEES

Mr. Roy C. Albert
ERDEC
ATTN: SCBAD-ASC
APG MD 21010-5423
(410) 671-4438 x

Ms. Kelly D. Alexander
Mobile Electric Power
7798 Cissna Road, Suite 200
Springfield VA 22150
(703) 355-2779 x

Mr. Joseph A. Andrese
US Army Research Lab
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 21010-5423
(410) 671-2045 x

Mr. Frank A. Avenoso
NAWC/Platform Interface Group
Naval Air Engineering Station
Rt. 547
LakeHurst NJ 08733-5000
(908) 323-7353 x

Mr. David F. Bassett
US Army Research Laboratory
ATTN: AMSRL-SL-I, Bldg. 433
Aberdeen Proving Grd MD 21050
(410) 278-8624 x

Mr. Timothy J. Bauer
NSWC- Dahlgren Division
Code B51, 17320 Dahlgren Road
Dahlgren VA 22448-5100
(703) 663-8621 x

Mr. Dennis W. Baylor
US Army Research Laboratory
ATTN: AMSRL-SL-CM
Aberdeen Proving Gr MD 21010-5423
(410) 671-3952 x

Mr. John Bailfuss
U.S. Army Research Lab
2800 Powder Mill Road
Adelphi MD 20783-1197
(301) 394-2852 x

Mr. Frank J. Belcastro
US Army ERDEC
ATTN: SCBRD-CE/MICAD
Bldg. E3549 Rm. C506
Aberdeen Proving Gr MD 21010-5423
(410) 671-5625 x

Mr. Marc Bernier
French Embassy
Defense Corp. Office
4101 Reservoir Road, NW
Washington DC 20007-2172
(202) 944-6461 x

Mr. Andrej Bevec
Army Research Lab
AMSRL-SL-CD
APG MD 21010-5423
(410) 671-2260 x

COL Ray W. Bills (Ret.)
Battelle Columbus Operations
JN-4
505 King Avenue
Columbus OH 43201-2693
(614) 424-7283 x

Dr. Amnon Birenzvige
US Army Edgewood RDE Center
Attn: SCBRD-AST
Aberdeen Proving Gd MD 21010-5423
(410) 671-8431 x

Mr. Robert A. Blankenbiller
USAMSAA
ATTN: AMXSY-CB
Aberdeen Proving Gr MD 21005-5071
(410) 278-3961 x

Ms. Heather D. Brinton
ADPA
Suite 400
2101 Wilson Boulevard
Arlington VA 22201
(703) 379-9182 x

Ms. Marguerite E. Brooks
UTD
3580 Cinderbend Road
Newington VA 22122
(410) 668-7323 x

Ms. Thea Buchanan
Kaiser Electronics
2701 Orchard Parkway
MS 65
San Jose CA 95134
(408) 432-3000 x1154

Mr. Jack R. Burden Sr.
Calspan Corporation
P O Box 1405
Springfield VA 22151-0405
(703) 323-5633 x

Mr. E. Knight Campbell
Techmatics, Inc.
Suite 1000, 2231 Crystal Drive
Arlington VA 22202
(703) 521-3818 x

Mr. Joseph H. Cappello
Calspan Corporation
4455 Genesee Street
P.O. Box 400
Buffalo NY 14225-0400
(716) 592-7331 x

Mr. Mikey N. Carroll
USAMSAA
ATTN: AMXSY-CB
Aberdeen Proving Gr MD 21005-5071
(410) 278-6864 x

Mr. Warren B. Carroll
Battelle Memorial Institute
505 King Avenue
Columbus OH 43081
(614) 424-4743 x

Mr. Ross A. Cuse
.S. Army Tank Automotive Command
TACOM-AMSTH-USS
Warren MI 48397-5000
(810) 574-6386 x

Mr. William Castner
Raytheon Missile Systems Division
180 Hartwell Road
Bedford MA 01730
(617) 274-3028 x

Mr. Robert Chase
3M
6801 River Place Blvd.
Austin TX 78726-9000
(512) 984-5688 x

Mr. Roger J. Chmura
Eltech Research Corporation
625 East Street
Fairport Harbor OH 44077
(216) 357-4034 x

Ms. Kathleen M. Considine
Chamberlain MRC
336 Clubhouse Lane
Hunt Valley MD 21030
(410) 527-7527 x

Mr. Fred Crowson
Asst. Deputy Under SECNAV (S&S)
CP 5, Rm. 162
2211 Jeff Davis Hwy.
Arlington VA 22444-5107
(703) 602-2882 x

Mr. Michael I. D'Andries
Booz, Allen & Hamilton
Airport Square 8, Suite 150
891 Elkridge Landing Road
Linthicum MD 21090
(410) 684-6209 x

Mr. Lou D'Elicio
US Army Research Laboratory
ATTN: AMSRL-SL-NC
Aberdeen Proving Gd MD 21010-5423
(410) 671-3987 x

Dr. Charles N. Davidson
USA Nuclear & Chemical Agency
7150 Heller Loop, Suite 101
Springfield VA 22150-3107
(703) 355-2556 x

Dr. Adarsh Deepak
Science & Technology Corporation
101 Research Drive
Hampton VA 23666-1340
(804) 865-1894 x

Mr. Warren Dixon
HQ TRADOC
Dept. of Army
ATCO-SB
Ft. Monroe VA 23605
(804) 727-4413 x

Mr. Norman Dyer
General Dynamics Land Systems
P.O. Box 2074
Warren MI 48090-2074
(810) 825-7157 x

Mr. Kenneth S. Eng
US Army RD&E Center
ATTN: SCBRD-RT/ASM
Aberdeen Proving Gr MD 21010-5423
(410) 671-8206 x

Mr. David M. English
OptiMetrics Inc.
Suite 209
2107 Laurel Bush Road
Bel Air MD 21015-5423
(410) 569-0293 x

Mr. Dave A. Ennis
Raychem
MP 102-7638
300 Constitution Drive
Menlo Park CA 94025-1164
(415) 361-7670 x

Mr. Samuel L. Eure
Science & Technology Corp
101 Research Drive
Hampton VA 23666-1340
(804) 865-0467 x

Mr. Drew B. Farenwald
US Army Research Laboratory
ATTN: AMSRL-SL-CN
Aberdeen Proving Gr MD 21010-5423
(410) 671-2922 x

COL James T. Ferguson AUS (Ret.)
Technology Marketing
PO Box 987
Millersville MD 21108-0987
(410) 987-9111 x

Mr. John J. Franz
US Army Research Lab
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 21010-5423
(410) 671-2896 x

BG George E. Friel USA
Commander, CBDCOM
ATTN: AMSCB-CG
Aberdeen Proving Gr MD 21010-5423
(410) 671-4361 x

Mr. James M. Gehringer
USAF F-22 System Program Office
ASC/YFEX, 2130 Fifth Street
Wright-Patterson AFB OH 45433
(513) 255-4976 x

Mr. Hugh Griffis
USAF
ATTN: ASC/XRESV, Bldg. 450
2645 Fifth Street
Wright-Patterson AF OH 45433-7003
(513) 255-2353 x

Mr. Robert A. Gross
USAEHA
Health Hazard Assessment Ofc.
ATTN: HSHB-MO-A
APG MD 21010-5422
(410) 671-2925 x

LTC James S. Hansen
Joint Program Office for Bio. Def
Attn: SFAE-BD, Skyline 5
Rm 401, 5111 Leesburg Pike
Falls Church VA 22041
(703) 756-0468 x

Ms. Barbara T. Hegdahl
Bell Helicopter Textron, Inc.
.O. Box 482, Dept. 81
MS #1401
Fort Worth TX 76101
(817) 280-5770 x

Mr. Hugh A. Herbig
Computer Sciences Corporation
MC 212
3170 Fairview Park Drive
Falls Church VA 22042-4528
(703) 641-2322 x

BG Peter D. Hidalgo USA (Ret.)
CSC Professional Services Group
.O. Box 333
Waverly Hall GA 31831-0333
(706) 382-3821 x

Mr. Tom Hippensteele
Computer Sciences Corporation
2107 Laurel Bush Road, Ste 206
Bel Air MD 21015-8932
(410) 579-4144 x

Mr. Jeffery S. Hoene
US Army RD&E Center
ATTN: SCBRD-RT/ASM
Aberdeen Proving Gr MD 21010-5423
(410) 671-3592 x

W. Bruce Holt
ADPA
Two Colonial Place, Suite 400
2101 Wilson Boulevard
Arlington VA 22201-3062
(703) 522-1820 x

Mr. Thomas A. Hrastich
PM-ALBE
ATTN: SFAE-AV-CSE
4300 Goodfellow Blvd.
St. Louis MO 63120
(314) 263-9149 x

Mr. William J. Hughes
US Army Research Lab
ATTN: AMSRL-SL-C, Bldg E-3331
Room 111
Aberdeen Prov Groun MD 21010-5423
(410) 671-8420 x

Mr. T.R. Hukkala
Titan Corporation
1900 Campus Commons Drive
Reston VA 22091
(703) 758-5741 x

Mr. Matthew I. Hutton
SAIC
626 Towne Center Drive
Suite 205
Joppa MD 21085
(410) 679-9800 x

Richard M. Jensen
USMC
DRPM AAA Clarendon SG Bldg.
3033 Wilson Blvd.
Arlington VA 22201-3803
(703) 696-1122 x

Mr. Keith Johanns
Battelle
505 King Avenue
Columbus OH 43201-2693
(614) 424-5804 x

Ms. Jane M. Johnson
BMY Combat Systems
United Defense LP
.O. Box 15512
York PA 17405-1512
(717) 225-4781 x2394

Mr. Edward Joiner CGE
Brunswick Defense
2000 Brunswick Lane
Deland FL 32724
(904) 736-1700 x

Mr. Steven A. Jones
CBIAC Battelle Edgewood Operation
2113 Emmerton Park Road
Suite 200
Edgewood MD 21040
(410) 676-9030 x

Mr. Matthew B. Kaufman
U.S. Army Research Laboratory
ATTN: AMSRL-SL-CM
Aberdeen Proving Gr MD 21010-5423
(410) 671-3958 x

Mr. Richard Keegan
Raytheon Co.
MS/1J7
528 Boston Road Post
Sudbury MA 01776
(508) 440-3073 x

Ms. Jennifer L. Kelley
US Army Research Lab
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 2110-5423
(410) 671-3716 x

Mr. Frank W. Kelly
GEOMET Technologies, Inc.
20251 Century Boulevard
Germantown MD 20874
(301) 428-9898 x

Mr. Michael O. Kierzewski
OptiMetrics, Inc.
Suite 209
2107 Laurel Bush Road
Bel Air MD 21015-6181
(410) 569-0293 x

TSGT Robert D. King
US Air Force
Det 63, ASC
2008 Stumpneck Road
Indian Head MD 20640
(301) 743-6826 x

Mr. Stephen L. Kistner
US Army EHA
ATTN: HSHB-ZA
APG MD 21010-5422
(410) 671-2307 x

Mr. Robert Lang
Loral Librascope Corporation
Program Manager
833 Sonora Ave.
Glendale CA 91201-2433
(818) 502-7289 x

Mr. Edward O. Lewis
US Army ARDEC
ATTN: AMCPM-MO
Picatinny Arsenal NJ 07806-5000
(201) 724-3977 x

Dr. John W. Lyons
US Army Research Laboratory
2800 Powder Mill Road
AMSRL-D
Adelphi MD 20783-1145
(301) 394-1600 x

Mr. William S. Magee Jr.
US Army CBDCOM
ATTN: AMSCB-EO
Aberdeen Proving Gr MD 21010-5423
(410) 671-3090 x

Mr. Francisco Magno
United Defense L.P.
1107 Coleman Avenue
Box 367
San Jose CA 95103
(408) 289-0551 x

Mr. John D. Majeski
US Army Research Laboratory
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 21010-5423
(410) 671-3943 x

Mr. Timothy D. Mallory
Army Research Laboratory
ATTN: AMSRL-SL-I
APG MD 21005-5068
(410) 278-6999 x

Mr. David J. Mangino
Calspan Corporation
.O. Box 400
4455 Genesee St.
Buffalo NY 14225-0400
(716) 592-7331 x

Dr. William J. Maurits
DoD Explosives Safety Board
2461 Eisenhower Avenue
Alexandria VA 22331
(703) 325-8624 x

Mr. James L. McKivrigan
CBDCOM
ATTN: AMSCB-EO
APG MD 21010-5423
(410) 671-3009 x

Mr. Tom M. McMahon
Calspan Corporation
P.O. Box 400
4455 Genesee Street
Buffalo NY 14225-0400
(716) 631-6905 x

Mr. James J. McNeely
Battelle-CBIAC
2113 Emmerton Park Road
Suite 200
Edgewood MD 21040-1037
(410) 676-9030 x

1LT Julio A. Medina
Pine Bluff Arsenal
ATTN: SMCPB-PCT
10020 Kabrich Circle
Pine Bluff AR 71602-9500
(501) 540-3072 x

Mr. Dennis F. Metz
EAI Corporation
1308 Continental Drive
Suite J
Abingdon MD 21009-2332
(410) 676-1449 x

Dr. Warren L. Miller
Camber Corporation
Suite 403
200 Valley Road
Mount Arlington NJ 07856-1320
(201) 770-1404 x

Mr. John Miner
Joint Program Office for Bio. Def.
SFAE-BD 5111 Leesburg Pike
Skyline 5 Rm. 401
Falls Church VA 22041
(703) 756-0468 x

Mr. Mark T. Mondell
United Defense LP
Combat Systems Division
P.O. Box 15512
York PA 17405-1512
(717) 225-4781 x

Mr. John S. Moorehead
Battelle Memorial Institute
505 King Ave. Room 13-4-177
Columbus OH 43201-2696
(614) 425-5056 x

Mr. Malcolm B. Morrison
SAIC
626 Towne Center Drive
Suite 205
Joppa MD 21085
(410) 679-9800 x

Mr. Robert K. Murk
US Army Research Laboratory
ATTN: AMSRL-SL-CO
Aberdeen Proving Gr MD 21010-5423
(410) 671-3820 x

Mr. George R. Murnyak
USAEHA
ATTN: HSHB-MO-A
APG MD 21010
(410) 671-2925 x

Mr. James J. Muthig
SAIC
Sikorsky Aircraft
6900 Main Street M/S B101A
Stratford CT 06601-1381
(203) 384-6739 x

Mr. James F. Myers
US Army Research Lab
ATTN: AMSRL-SL-CO
APG MD 21010-5423
(410) 671-2260 x

Mr. James F. Nealon
US Army Research Lab
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 21010-5423
(410) 671-3711 x

Mr. Dennis S. O'Connor
EOD Training and Evaluation
Unit Two E-6/Gunners
Mate Guns First Class Diver
Ft. Story VA 23459

Ms. Donna L. Orlando
US Army Research Lab
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 21010-5423
(410) 671-3031 x

Mr. Oliver J. Ozment
CSC Professional Services Group
Suite 203
3315 Bob Wallace Avenue
Huntsville AL 35805
(205) 534-3510 x

Mr. Shawn H. Park
McDonnell Douglas Aerospace
Dept. 2LT, M/C 35-95
3855 Lakewood Boulevard
Long Beach CA 90846-0003
(310) 593-6460 x

Mr. Walter G. Parks
JAYCOR
1608 Spring Hill Road
Vienna VA 22182-2270
(703) 847-4000 x

Mr. David Peart
.S. Army Dugway Proving Ground
ATTN: MT-TM-CB
Dugway UT 84022
(801) 831-5637 x

Mr. James E. Peavler
Chesapeake Development Inc.
P. O. Box 1130
Sparks MD 21152
(410) 472-2064 x

Mr. Ed J. Perri
USAMSAA
ATTN: AMXSY-CB
Aberdeen Proving Gr MD 21005-5071
(410) 679-4548 x

Mr. Roland J. Pilie
Calspan Corporation
P.O. Box 400
4455 Genesee Street
Buffalo NY 14225-0400
(716) 631-6895 x

Mr. Robert E. Plank Jr.
US Army RD&E Center
ATTN: SCBRD-RT/ASM
Aberdeen Proving Gr MD 21010-5423
(410) 671-1888 x

Mr. Roland A. Polimadei
US Army Research Lab
ATTN: AMSRL-SL-CE
2800 Powder Mill Road
Adelphi MD 20783-1145
(410) 671-3823 x

Mr. Albert W. Price
US Army Research Lab
ATTN: AMSRL-SL-CS
Aberdeen Proving Gr MD 21010-5423
(301) 671-3913 x

1LT Lisa Proby
Pine Bluff Arsenal
ATTN: SMCPB-HST
Pine Bluff AR 71602-9500
(501) 540-3072 x

Mr. Robert J. Puhala
US Army Edgewood RD&E Center
ATTN: SCBRD-AD
Aberdeen Proving Gr MD 21010-5423
(410) 671-5500 x

Mr. Albert Puzzuoli
PEO, Armored Systems Modernizatio
SFAE-ASM-AG
Warren MI 48397-0001
(313) 574-7714 x

Mr. Richard C. Renairi
US Army CECOM
10215 Burbeck Road
AMSEL-RD-NV-LPD
Fort Belvoir VA 22060-5806
(703) 704-1204 x

MAJ Michael Resty Jr.
US Army ODCSLOG
Pentagon Room 1C562
Washington DC 20310-0550
(703) 697-2557 x

Jan R. Roberts
SRS Technolgies
500 Discovery Drive NW
Huntsville AL 35758
(205) 971-7847 x

Mr. Donald L. Rowe
Naval Surface Warfare Center
Code J42
Dahlgren VA 22448
(703) 663-6802 x

Dr. Robert Rubio
ARL Battlefield Environment Dir.
ATTN: AMSRL-BE-A
White Sands Missile Range
WSMR NM 88002-5501
(505) 678-3331 x

LTC Melvin J. Schichtman (Ret.)
U.S. Army Research Lab
AMSRL-CP-T
2800 Powder Mill Road
Adelphi MD 20782-1145
(301) 394-5075 x

Dr. Lawrence D. Schwartz
Raychem Corporation
300 Constitution Drive
102/6535
Menlo Park CA 94029
(415) 361-3608 x

Mr. Wendel J. Shuely
ERDEC Research & Technology
SCBRD-RTC
APG EA MD 21040

LTC Melvin Silverman USA,(Ret.)
315 Tartan Green Court
Joppa MD 21085-4324
(301) 679-4476 x

Mr. Mark A. Silvestri
U.S. Army Research Lab
ATTN: AMSRL-SL-CM
Aberdeen Proving Gr MD 21010-5423
(410) 671-3960 x

Mr. Eduardo D. Soliven
US Army Nuclear & Chemical Agency
ATTN: MONA-CM
7150 Heller Loop, Suite 101
Springfield VA 22150-3107
(703) 355-2312 x

Mr. Jerry W. Steelman
US Army Dugway Proving Ground
ATTN: MT-TM
Dugway UT 84022
(801) 831-5241 x

Mr. Gary Stickel
Battelle
505 King Avenue
JN4
Columbus OH 43201-2693
(614) 424-7518 x

Mr. Garrison W. Still
Army Research Lab
AMSRL-SL-CS
Adelphi MD 20783-1197
(301) 394-5450 x

Mr. Russ Suchy
Mine Safety Appliances Company
.O. Box 428
Pittsburgh PA 15230-0428
(412) 733-9272 x

Ms. Debra L. Sutton
United Defense
MD/W50
1107 Coleman Avenue
San Jose CA 95103
(408) 289-3133 x

Major Jeff C. Switzer
HQ, US Army Test & Evaluation
Ryan Building
Aberdeen Proving Gd MD 21005-5057
(410) 278-1072 x

Mr. David Torgerson
U.S. Army Dugway Proving Ground
ATTN: MT-C
Dugway UT 84022
(801) 831-5226 x

Mr. Joseph A. Traino III
Science & Technology Corp.
Unit 1
2719 Pulaski Highway
Edgewood MD 21040-1315
(410) 272-4161 x

Mr. E. Michael Vogel
US Army Research Laboratory
AMSRL-SL-I
APG MD 21005-5068
(410) 278-5855 x

Mr. James J. Wade
US Army Research Lab
ATTN: AMSRL-SL/SLAD
WSMR NM 88002-5513
(505) 678-1196 x

Mr. Robert T. Walker
Cypress International, Inc.
Suite 400
1201 E. Abingdon Drive
Alexandria VA 22314-1490
(703) 549-5880 x

Ms. Annetta Watson
Oak Ridge National Laboratory
.O. Box 2008
Oak Ridge TN 37831

Mr. Philip Weinberg
Naval Air Systems Command
AIR 516J, JTC G/AS
1421 Jefferson Davis Highway
Arlington VA 22243-5160
(703) 325-0165 x

Dr. Ronald A. Weiss
US Army Research Lab
ATTN: AMSRL-SL-CS/E3331
Room 120
Aberdeen Proving Gr MD 21010-5423
(410) 671-8429 x

Mr. Ngai Wong
U.S. Air Force Armstrong
ATTN: USAF AL/CFBD, Bldg.E3234
APG MD 21010-5423
(410) 671-3111 x

Mr. Charles R. Yarbrough
Lockheed Ft. Worth Company
101 Academy Blvd.
Fort Worth TX 76108
(817) 935-4511 x

Mr. Daniel K. Yu
HQ AMC
ATTN: AMCCB
Alexandria VA 22331-0001
(703) 274-9520 x

LIST OF EXHIBITS

Intentionally Left Blank

LIST OF EXHIBITS

	EXHIBITOR	THEME
1)	Calspan Corporation	Capabilities Overview
2)	Battelle	Chemical Defense Materials Database (CDMD) Demonstration
3)	Battelle	Chemical Warfare/Chemical and Biological Defense Information Analysis Center (CBIAC) Resources
4)	Battelle	Capabilities Overview
5)	DoD Project Manager for Mobile Electric Power/Camber Corporation	Tactical Quiet Generator
6)	Product Manager for Smoke/Obscurants	XM56 Large Area Smoke Generator Static Display
7)	U.S. Army CBDCOM	Capabilities Overview
8)	U.S. Army CBDCOM/Loral Librascope	Multipurpose Integrated Chemical Agent Alarm (MICAD) Operational Demonstration
9)	U.S. Army Nuclear and Chemical Agency (USANCA)	Capabilities Overview
10)	U.S. Army Research Laboratory	Ballistic Vulnerability and Lethality Division: BRL-CAD Demonstration
11)	U.S. Army Research Laboratory	Capabilities Overview: Chemical-Biological and Nuclear Effects Division

Intentionally Left Blank

NO. OF COPIES	ORGANIZATION
2	ADMINISTRATOR DEFENSE TECHNICAL INFO CENTER ATTN: DTIC-DDA CAMERON STATION ALEXANDRIA VA 22304-6145
1	COMMANDER US ARMY MATERIEL COMMAND ATTN: AMCAM 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-OP-SD-TA/ RECORDS MANAGEMENT 2800 POWDER MILL RD ADELPHI MD 20783-1145
3	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-OP-SD-TL/ TECHNICAL LIBRARY 2800 POWDER MILL RD ADELPHI MD 20783-1145
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-OP-SD-TP/ TECH "UBLISHING BRANCH 2800 POWDER MILL RD ADELPHI MD 20783-1145
2	COMMANDER US ARMY ARDEC ATTN: SMCAR-TDC PICATINNY ARSENAL NJ 07806-5000
1	DIRECTOR BENET LABORATORIES ATTN: SMCAR-CCB-TL WATERVLIET NY 12189-4050
1	DIRECTOR US ARMY ADVANCED SYSTEMS RESEARCH AND ANALYSIS OFFICE ATTN: AMSAT-R-NR/MS 219-1 AMES RESEARCH CENTER MOFFETT FIELD CA 94035-1000

NO. OF COPIES	ORGANIZATION
1	COMMANDER US ARMY MISSILE COMMAND ATTN: AMSMI-RD-CS-R (DOC) REDSTONE ARSENAL AL 35898-5010
1	COMMANDER US ARMY TANK-AUTOMOTIVE COMMAND ATTN: AMSTA-JSK (ARMOR ENG BR) WARREN MI 48397-5000
1	DIRECTOR US ARMY TRADOC ANALYSIS COMMAND ATTN: ATRC-WSR WSMR NM 88002-5502
1	COMMANDANT US ARMY INFANTRY SCHOOL ATTN: ATSH-WCB-O FORT BENNING GA 31905-5000
	ABERDEEN PROVING GROUND
2	DIR, USAMSAA ATTN: AMXSY-D AMXSY-MP/H COHEN
1	CDR, USATECOM ATTN: AMSTE-TC
1	DIR, USAERDEC ATTN: SCBRD-RT
1	CDR, USACBDCOM ATTN: AMSCB-CII
1	DIR, USARL ATTN: AMSRL-SL-I
5	DIR, USARL ATTN: AMSRL-OP-AP-L

NO. OF COPIES	ORGANIZATION
1	US ARMY ODCSLOG ATTN: MAJ MICHAEL RESTY JR PENTAGON, ROOM 1C562 WASHINGTON DC 20310-0550
1	DOD EXPLOSIVES SAFETY BOARD ATTN: DR WILLIAM J MAURITS 2461 EISENHOWER AVE ALEXANDRIA VA 22331
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-D/DR JOHN W LYONS 2800 POWDER MILL ROAD ADELPHI MD 20783-1145
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-BE-A/DR ROBERT RUBIO WSMR NM 88002-5501
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-SL/MR JAMES J WADE WSMR NM 88002-5501
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-CP-T/ LTC MELVIN J SCHICHTMAN 2800 POWDER MILL ROAD ADELPHI MD 20782-1145
1	DIRECTOR US ARMY RESEARCH LABORATORY ATTN: AMSRL-SL-CS/ MR GARRISON W STILL 2800 POWDER MILL ROAD ADELPHI MD 20783-1197
1	US ARMY CECOM ATTN: AMSEL-RD-NV-LPD/ MR RICHARD C RENAIRI 10215 BURBECK RD FORT BELVOIR VA 22060-5806
1	US ARMY DUGWAY PROVING GROUND ATTN: MT-C/MR DAVID TORGERSON DUGWAY UT 84022

NO. OF COPIES	ORGANIZATION
1	US ARMY DUGWAY PROVING GROUND ATTN: MT-TM/MR JERRY W STEELMAN DUGWAY UT 84022
1	US ARMY DUGWAY PROVING GROUND ATTN: MT-TM-CB/MR DAVID PEART DUGWAY UT 84022
2	US ARMY NUCLEAR & CHEMICAL AGENCY ATTN: MONA-CM/MR EDUARDO D SOLIVEN DR CHARLES N DAVIDSON 7150 HELLER LOOP, SUITE 101 SPRINGFIELD VA 22150-3107
1	COMMANDER US ARMY ARDEC ATTN: AMCPM-MO/MR EDWARD O LEWIS PICATINNY ARSENAL NJ 07806-5000
1	COMMANDER US ARMY TANK AUTOMOTIVE COMMAND ATTN: TACOM-AMSTH-USSS/MR ROSS A CASE WARREN MI 48397-5000
1	USAF DET 63, ASC ATTN: TSGT ROBERT D KING 2008 STUMPNECK ROAD INDIAN HEAD MD 20640
1	USAF F-22 SYSTEM PROGRAM OFFICE ATTN: ASC/YFEX/MR JAMES M GEHRINGER 2130 FIFTH STREET WRIGHT-PATTERSON AFB OH 45433
1	USAF ATTN: ASC/XRESV/MR HUGH GRIFFIS BLDG 450, 2645 FIFTH STREET WRIGHT-PATTERSON AFB OH 45433
2	ADPA ATTN: MS HEATHER D BRINTON MR W BRUCE HOLT TWO COLONIAL PLACE, SUITE 400 2101 WILSON BOULEVARD ARLINGTON VA 22201-3062
1	MOBILE ELECTRIC POWER ATTN: MS KELLY D ALEXANDER 7798 CISSNA ROAD, SUITE 200 SPRINGFIELD VA 22150

NO. OF COPIES	ORGANIZATION
1	NAWC/PLATFORM INTERFACE GROUP NAVAL AIR ENGINEERING STATION ATTN: MR FRANK A AVENOSO ROUTE 547 LAKEHURST NJ 08733-5000
2	NAVAL SURFACE WARFARE CENTER DAHLGREN DIVISION ATTN: TIMOTHY J BAUER/CODE B51 MR DONALD L ROWE/CODE J42 17320 DAHLGREN ROAD DAHLGREN VA 22448-5100
2	BATTELLE ATTN: JN4/ COL RAY W BILLS (RET) MR GARY STICKEL 505 KING AVE COLUMBUS OH 43201-2693
2	BATTELLE ATTN: MR KEITH JOHANNS MR WARREN B CARROLL 505 KING AVE COLUMBUS OH 43201-2696
1	UTD ATTN: MS MARGUERITE E BROOKS 3580 CINDERBEND ROAD NEWINGTON VA 22122
1	SCIENCE AND TECHNOLOGY CORPORATION UNIT 1 ATTN: MR JOSEPH A TRIANO III 2719 PULASKI HIGHWAY EDGEWOOD MD 21040-1315
2	SCIENCE AND TECHNOLOGY CORPORATION ATTN: MR SAMUEL L EURE DR ADARSH DEEPAK 101 RESEARCH DR HAMPTON VA 23666-1340
1	OAK RIDGE NATIONAL LABORATORY ATTN: MS ANNETTA WATSON PO BOX 2008 OAK RIDGE TN 37831
1	LOCKHEED ATTN: MR CHARLES R YARBROUGH 101 ACADEMY BLVD FORT WORTH TX 76108

NO. OF COPIES	ORGANIZATION
1	CYPRESS INTERNATIONAL INC ATTN: MR ROBERT T WALKER 1201 E ABINGDON DR, SUITE 400 ALEXANDRIA VA 22314-1490
1	NAVAL AIR SYSTEMS COMMAND AIR 516J, JTC G/AS ATTN: MR PHILIP WEINBERG 1421 JEFFERSON DAVIS HIGHWAY ARLINGTON VA 22243-5160
1	HQ AMC ATTN: AMCCB/MR DANIEL K YU ALEXANDRIA VA 22331-0001
1	SRS TECHNOLOGIES ATTN: JAN R ROBERTS 500 DISCOVERY DRIVE NW HUNTSVILLE AL 35758
2	RAYCHEM CORPORATION ATTN: MP 102/6535/DR LAWRENCE J SCHWARTZ MP 102/6738/MR DAVE A ENNIS 300 CONSTITUTION DR MENLO PARK CA 94029
1	MINE SAFETY APPLIANCES COMPANY ATTN: MR RUSS SUCHY PO BOX 428 PITTSBURGH PA 15230-0428
1	PEO-ARMORED SYSTEMS MODERNIZATION ATTN: SFAE-ASM-AG/MR ALBERT PUZZUOLI WARREN MI 48397-0001
1	UNITED DEFENSE LP ATTN: MD/W50/MS DEBRA L SUTTON 1107 COLEMAN AVE SAN JOSE CA 95103
1	UNITED DEFENSE LP ATTN: MR FRANCISCO MAGNO 1107 COLEMAN AVE, BOX 367 SAN JOSE CA 95103
1	UNITED DEFENSE LP COMBAT SYSTEMS DIVISION ATTN: MR MARK T MONDELL PO BOX 15512 YORK PA 17405-1512

NO. OF COPIES	ORGANIZATION
1	UNITED DEFENSE LP BMY COMBAT SYSTEMS ATTN: MS JANE M JOHNSON PO BOX 15512 YORK PA 17405-1512
1	SAIC SIKORSKY AIRCRAFT ATTN: MR JAMES J MUTHIG 6900 MAIN STREET/MS B101A STRATFORD CT 06601-1381
2	SAIC ATTN: MR MALCOLM B MORRISON MR MATTHEW I HUTTON 626 TOWNE CENTER DRIVE, SUITE 205 JOPPA MD 21085
1	MCDONNELL DOUGLAS AEROSPACE ATTN: MR SHAWN H PARK DEPT 2LT/MC 35-95 3855 LAKEWOOD BLVD LONG BEACH CA 90846-0003
1	EOD TRAINING AND EVALUATION UNIT TWO E-6/GUNNERS MATE GUNS FIRST CL/ S DIVER ATTN: MR DENNIS S O'CONNOR FT STORY VA 23459
1	CSC PROFESSIONAL SERVICES GROUP ATTN: MR OLIVER J OZMENT SUITE 203, 3315 BOB WALLACE AVE HUNTSVILLE AL 35805
1	JAYCOR ATTN: MR WALTER G PARKS 1608 SPRING HILL ROAD VIENNA VA 22182-2270
1	CHESAPEAKE DEVELOPMENT INC ATTN: MR JAMES E PEAVLER PO BOX 1130 SPARKS MD 21152
4	CALSPAN CORPORATION ATTN: MR ROLAND J PILIE MR DAVID J MANGINO MR TOM M MCMAHON MR JOSEPH H CAPPELO PO BOX 400 BUFFALO NY 14225-0400

NO. OF COPIES	ORGANIZATION
1	CALSPAN CORPORATION ATTN: MR JACK R BURDEN, SR PO BOX 1405 SPRINGFIELD VA 221510405
2	PINE BLUFF ARSENAL ATTN: SMCPB-HST/1LT LISA PROBY SMCPB-PCT/1LT JULIO A MEDINA 10020 KABRICH CIRCLE PINE BLUFF AR 71602-9500
2	BATTELLE ATTN: MR JAMES J MCNEELY MR STEVEN A JONES 2113 EMMORTON PARK RD, SUITE 200 EDGEWOOD MD 21040-1087
1	EAI CORPORATION ATTN: MR DENNIS F METZ 1308 CONTINENTAL DR, SUITE J ABINGDON MD 21009-2332
2	JOINT PROGRAM OFFICE FOR BIO DEF ATTN: SFAE-BD, MR JOHN MINER LTC JAMES S HANSEN SKYLINE 5, RM 401 5111 LEESBURG PIKE FALLS CHURCH VA 22041
1	CAMBER CORPORATION ATTN: DR WARREN L MILLER SUITE 403, 200 VALLEY ROAD MOUNT ARLINGTON NJ 07856-1320
1	PM-ALSE ATTN: SFAE-AV-CSE/ MR THOMAS A HRASTICH 4300 GOODFELLOW BLVD ST LOUIS MO 63120
1	TITAN CORPORATION ATTN: MR T R HUKKALA 1900 CAMPUS COMMONS DRIVE RESTON VA 22091
1	USMC ATTN: RICHARD M JENSEN DRPM AAA CLARENDON SQ BLDG 3033 WILSON BLVD ARLINGTON VA 22201-3803

NO. OF COPIES	ORGANIZATION
1	RAYTHEON CO ATTN: MR RICHARD KEEGAN/MS-1J7 528 BOSTON POST ROAD SUDBURY MA 01776
1	RAYTHEON MISSILE SYSTEMS DIVISION ATTN: MR WILLIAM CASTNER 180 HARTWELL ROAD BEDFORD MA 01730
1	ELTECH RESEARCH CORPORATION ATTN: MR ROGER J CHMURA 625 EAST STREET FAIRPORT HARBOR OH 44077
1	ASST DEPUTY UNDER SECNAV (S&S) ATTN: MR FRED CROWSON CP 5, RM 162 2211 JEFFERSON DAVIS HIGHWAY ARLINGTON VA 22444-5107
1	GEOMET TECHNOLOGIES INC ATTN: MR FRANK W KELLY 20251 CENTURY BLVD GERMANTOWN MD 20874
1	BRUNSWICK DEFENSE ATTN: MR EDWARD JOINER 2000 BRUNSWICK LANE DE LAND FL 32724
2	OPTIMETRICS INC ATTN: MR MICHAEL O KIERZEWSKI MR DAVID M ENGLISH 2107 LAUREL BUSH ROAD, SUITE 209 BEL AIR MD 21015-6181
1	LORAL LIBRASCOPE CORPORATION ATTN: MR ROBERT LANG, PROGRAM MANAGER 833 SONORA AVE GLENDALE CA 91201-2433
1	BELL HELICOPTER TEXTRON INC ATTN: MS BARBARA T HEGDAHL/MS #1401 PO BOX 482, DEPT 81 FORT WORTH TX 76101
1	CSC PROFESSIONAL SERVICES GROUP ATTN: BG PETER D HIDALGO, USA (RET) PO BOX 333 WAVERLY HALL GA 31831-0333

NO. OF COPIES	ORGANIZATION
1	TECHNOLOGY MARKETING ATTN: COL JAMES T FERGUSON, USA (RET) PO BOX 987 MILLERSVILLE MD 21108-0987
1	COMPUTER SCIENCES CORPORATION ATTN: MR HUGH A HERBIG/MC 212 3170 FAIRVIEW PARK DR FALLS CHURCH VA 22042-4528
1	COMPUTER SCIENCES CORPORATION ATTN: MR TOM HIPPENSTEELE 2107 LAUREL BUSH ROAD, SUITE 206 BEL AIR MD 21015-8932
1	KAISER ELECTRONICS ATTN: MS THEA BUCHANAN/MS 65 2701 ORCHARD PARKWAY SAN JOSE CA 95134
1	TECHMATICS INC ATTN: MR E KNIGHT CAMPBELL SUITE 1000, 2231 CRYSTAL DRIVE ARLINGTON VA 22202
1	3M ATTN: MR ROBERT CHASE 6801 RIVER PLACE BLVD AUSTIN TX 78726-9000
1	CHAMBERLAIN MRC ATTN: MS KATHLEEN M CONSIDINE 336 CLUBHOUSE LANE HUNT VALLEY MD 21030
1	BOOZ, ALLEN & HAMILTON ATTN: MR MICHAEL I D'ANDRIES AIRPORT SQUARE 8, SUITE 150 891 ELKRIDGE LANDING ROAD LINTHICUM MD 21090
1	HQ TRADOC ATTN: ATCO-SB/MR WARREN DIXON FT MONROE VA 23605
1	GENERAL DYNAMICS LAND SYSTEMS ATTN: MR NORMAN DYER PO BOX 2074 WARREN MI 48090-2074

NO. OF COPIES	ORGANIZATION
1	LTC MELVIN SILVERMAN, USA (RET) 315 TARTAN GREEN COURT JOPPA MD 21085-4324

ABERDEEN PROVING GROUND

NO. OF COPIES	ORGANIZATION
3	CDR, USAARDEC ATTN: SCBRD-RT-ASM/ MR KENNETH S ENG MR JEFFERY S HOENE MR ROBERT E PLANK, JR
5	DIR, USAERDEC ATTN: SCBRD-AD/MR ROBERT J PUHALA SCBRD-ASC/MR ROY C ALBERT SCBRD-CE/MR FRANK J BELCASTRO SCBRD-AST/DR AMNON BIRENZVIGE SCBRD-RTC/MR WENDEL J SHUELY
3	CDR, USACBDCOM ATTN: AMSCB-CG/BG GEORGE E FRIEL AMSCB-EO/ MR WILLIAM S MAGEE, JR MR JAMES L MCKIVRIGAN
3	DIR, USAMSAA ATTN: AMXSY-CB/ MR ROBERT A BLANKENBILLER MR MIKEY N CARROLL MR ED J PERRI
3	DIR, USAEHA ATTN: HSHB-MO-A/ MR ROBERT A GROSS MR GEORGE R MURNYAK HSHB-ZA/MR STEPHEN L KISTNER
1	CDR, USATECOM ATTN: MAJ JEFF C SWITZER
47	DIR, USARL ATTN: AMSRL-SL-C/MR WILLIAM J HUGHES AMSRL-SL-CD/MR ANDREJ BEVEC AMSRL-SL-CE/MR ROLAND A POLIMADEI AMSRL-SL-CM/ MR LOU E'ELICIO (26 CP) MR DENNIS W BAYLOR MR DREW B FARENWALD MR MATTHEW B KAUFMAN MR MARK A SILVESTRI AMSRL-SL-CO/ MR ROBERT K MURK MR JAMES F MYERS AMSRL-SL-CS/ MR JOHN BEILFUSS MR JOSEPH A ANDRESE MR JOHN J FRANZ MS JENNIFER L KELLEY MR JOHN D MAJESKI MR JAMES F NEALON MS DONNA ORLANDO MR ALBERT W PRICE MR RONALD A WEISS AMSRL-SL-I/ MR DAVID F BASSETT MR TIMOTHY D MALLORY MR E MICHAEL VOGEL
1	US AIR FORCE ARMSTRONG ATTN: USAF AL/CFBD/MR NGAI WONG BLDG E3234

NO. OF COPIES	ORGANIZATION
1	FRENCH EMBASSY DEFENSE CORP OFFICE ATTN: MR MARC BERNIER 4101 RESERVOIR ROAD NW WASHINGTON DC 20007-2172

INTENTIONALLY LEFT BLANK.

USER EVALUATION SHEET/CHANGE OF ADDRESS

This Laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers to the items/questions below will aid us in our efforts.

1. ARL Report Number ARL-CR-189 Date of Report October 1994

2. Date Report Received ____________________

3. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.) ____________________

4. Specifically, how is the report being used? (Information source, design data, procedure, source of ideas, etc.) ____________________

5. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided, or efficiencies achieved, etc? If so, please elaborate. ____________________

6. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.) ____________________

CURRENT ADDRESS

Organization

Name

Street or P.O. Box No.

City, State, Zip Code

7. If indicating a Change of Address or Address Correction, please provide the Current or Correct address above and the Old or Incorrect address below.

OLD ADDRESS

Organization

Name

Street or P.O. Box No.

City, State, Zip Code

(Remove this sheet, fold as indicated, tape closed, and mail.)

(DO NOT STAPLE)